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# **Drivers and barriers for a modal shift from road to maritime transportation within construction logistics**

A comparison of cases from Sweden

Master's Thesis in the Master's Programme  
Supply Chain Management

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A black and white shallow focus photography of a rope in a port

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## Abstract

Sweden has the longest coast in the EU, and several ports spread all along the coast. Despite the amounts of suitable waterways, goods volumes are concentrated on the main sea-ports in Gothenburg and Helsingborg. In an official report, the capacity for inland waterway transport in Sweden today is described as massively under-utilized. The waterway passages around Värnern, Göta älv, and Mälaren are barely utilized, and there is no feeder-traffic between the sea-ports along the coast. In a country such as Sweden, with an outspoken goal to be at the forefront of sustainability, having close to no internal waterway utilization is a failure.

In areas such as construction logistics, where the goods are usually of low value, high volume, and multiple specific shapes, waterway transportation should be feasible. There are several areas in Sweden under heavy construction at the moment. For example, the areas in and around central Gothenburg and Stockholm on Sweden's coasts are currently facing some of their largest construction reformations ever.

Thus, this thesis was created to examine what prevents and what empowers a modal shift from road to maritime transportation, which led to the formulation of a purpose *to investigate the feasibility of a modal shift for construction material from road to waterway transportation in Sweden by examining cases where such a modal change has been carried out or planned. Further, the thesis aims to identify barriers and drivers in these cases and make suggestions on which action could be taken in order to support a modal shift.* In order to resolve this, three research questions were constructed. First and second, what drivers and what barriers are identified by literature and people in the industry, and third, what can be done to overcome the barriers identified and how to accentuate the drivers?

Through a study, where interviews with stakeholders in five different cases in Sweden was conducted, the main drivers were identified as reduced emissions and congestion, the proximity of waterways, technical benefits from barges and sea vessels and finally the possibility to achieve economies of scale. Further on, the main barriers identified where: habit and prejudice, flawed national incentive systems, fees related to the utilization of maritime transportation, the requirement of extra points of transshipment, lack of knowledge, flexibility performance, high investment costs for each transport and investment costs related to infrastructure. In order to overcome barriers and accentuate drivers, the results illustrate that municipal and governmental instances require to start making higher demands, change the way they construct incentive systems and incite proactiveness. The construction companies need to start considering maritime as a viable option from the procurement phase. Knowledge among governmental and municipal employees was also identified as a barrier. Increased awareness of the benefits of maritime transportation would supposedly lead to higher investments in infrastructure from different governmental instances and thus reduce the infrastructural barrier.

# Table of content

<b>1. INTRODUCTION</b>	<b>1</b>
<b>1.1 GLOBAL AND EUROPEAN MARITIME TRANSPORTATION</b>	<b>1</b>
<b>1.2 MARITIME TRANSPORTATION AND CONSTRUCTION LOGISTICS IN SWEDEN</b>	<b>1</b>
<b>1.3 TREND TOWARDS SUSTAINABLE TRANSPORTATION</b>	<b>2</b>
<b>1.4 PURPOSE</b>	<b>2</b>
<b>1.5 PROBLEM FORMULATION AND RESEARCH QUESTIONS</b>	<b>2</b>
<b>1.6 SCOPE AND LIMITATIONS</b>	<b>3</b>
<b>2. FRAME OF REFERENCE</b>	<b>4</b>
<b>2.1 MARITIME TRANSPORTATION</b>	<b>4</b>
2.1.1 SHORT-SEA AND COASTAL SHIPPING	4
2.1.2 INLAND WATERWAY TRANSPORTATION	5
2.1.3 SHIPS AND VESSELS	5
<b>2.2 ROAD TRANSPORTATION</b>	<b>5</b>
<b>2.3 CONSTRUCTION LOGISTICS</b>	<b>6</b>
<b>2.4 SUSTAINABLE DEVELOPMENT</b>	<b>7</b>
<b>2.5 DRIVERS MODAL SHIFT</b>	<b>7</b>
2.5.1 LAWS AND REGULATIONS	7
2.5.2 FINANCIAL	8
2.5.3. INFRASTRUCTURE	9
2.5.4 ENVIRONMENTAL	9
2.5.5 SUMMARY OF DRIVERS	10
<b>2.6 BARRIERS FOR A MODAL SHIFT</b>	<b>11</b>
2.6.1 LAWS AND REGULATIONS	11
2.6.2 FINANCIAL	11
2.6.3 INFRASTRUCTURAL	13
2.6.4 SERVICE QUALITY	13
2.6.5 ADMINISTRATIVE	14
2.6.6 SUMMARY OF BARRIERS	14
<b>3. METHODOLOGY</b>	<b>15</b>
<b>3.1 RESEARCH STRATEGY AND DESIGN</b>	<b>15</b>
<b>3.2 FRAME OF REFERENCE</b>	<b>15</b>
<b>3.3 DATA COLLECTION</b>	<b>15</b>
3.3.1 CASE SELECTION	16
<b>3.4 ANALYSIS</b>	<b>16</b>
<b>4. CASE STUDIES</b>	<b>18</b>
<b>4.1 UDDEVALLA (GOTHENBURG)</b>	<b>18</b>

<b>4.2 KARLSTAD</b>	<b>19</b>
<b>4.3 STOCKHOLM</b>	<b>19</b>
4.3.1 SLUSSEN	20
4.3.2 STOCKHOLM BYPASS	21
<b>4.4 HELSINGBORG</b>	<b>22</b>
<b>4.5 SUMMARY OF THE CASES EXAMINED</b>	<b>22</b>
<b>5. RESULTS</b>	<b>23</b>
<b>5.1 UDDEVALLA</b>	<b>24</b>
<b>5.2 KARLSTAD</b>	<b>26</b>
<b>5.3 SLUSSEN</b>	<b>27</b>
<b>5.4 THE STOCKHOLM BYPASS PROJECT</b>	<b>29</b>
<b>5.5 HELSINGBORG</b>	<b>30</b>
<b>5.6 EXPERTS</b>	<b>32</b>
<b>6. ANALYSIS</b>	<b>35</b>
<b>6.1 DRIVERS AND BARRIERS</b>	<b>35</b>
6.1.1 LAWS AND REGULATIONS	35
6.1.2 FINANCIAL	36
6.1.3 INFRASTRUCTURE	37
6.1.4 ENVIRONMENTAL	38
6.1.5 SERVICE QUALITY	39
6.1.6 ADMINISTRATIVE	39
6.1.7 OTHER	40
<b>6.2 CASES - A COMPARISON</b>	<b>40</b>
6.2.1 DRIVERS	41
6.2.2 BARRIERS	41
<b>6.3 ACTORS AND ROLES – A COMPARISON</b>	<b>41</b>
6.3.1 DRIVERS	41
6.3.1.1 Laws and regulations	41
6.3.1.2 Financial	41
6.3.1.3 Infrastructure	42
6.3.1.4 Environmental	42
6.3.2 BARRIERS	42
6.3.2.1 Laws and regulations	42
6.3.2.2 Financial	42
6.3.2.4 Infrastructure	43
6.3.2.5 Environmental	43
6.3.2.6 Service quality	43
6.3.2.6 Administrative	43
6.3.2.7 Other	44
<b>6.4 RECOMMENDATIONS</b>	<b>44</b>
<b>6.5 REFLECTIONS</b>	<b>45</b>
6.5.1 JIT DELIVERIES	45
6.5.2 LACKING PROACTIVENESS	45

6.5.3 QUANTIFICATION OF COSTS	45
6.5.4 CONTRIBUTION TO PREVIOUS RESEARCH	45
6.5.5 FUTURE AREA OF RESEARCH	46
<b>7. CONCLUSIONS</b>	<b>47</b>
<hr/>	
7.1 RESEARCH QUESTION ONE	47
7.2 RESEARCH QUESTION TWO	47
7.2 RESEARCH QUESTION THREE	47
<b>8. REFERENCES</b>	<b>49</b>
<hr/>	

# 1. Introduction

*In the introduction, the background and purpose of the paper are explained. Further, research questions are formulated, and the scope and limitations are described, and an outline of the thesis provided.*

## 1.1 Global and European maritime transportation

In the last fifty years, the distance between the average consumer and producer has doubled (BVB, 2017). Freight transportation is that which enables the consumption and trade over vast distances, making it vital for the global economy (Crainic, 2007). There are several ways to conduct freight transportation, where the truck, train, and maritime transportation are the most common. While truck might dominate the shorter distances, for longer hauls maritime is more suitable due to its cost efficiency (Lumsden, 2007). One example of this is from the EU (IVA & Sveriges Byggindustrier, 2014), where the maritime transportation sector stands for up to 90% of the European Union's external freight. Given the strengths of the transportation mode being its ability to carry large amounts of goods with a relatively small cost on the environment and the economy over vast distances makes it the obvious choice.

However, between the member states in the European Union, the transportation mode is far from used to its potential. In the European Union, approximately 49% of total freight transportation is conducted by road transportation (the division is illustrated in Figure 1.).

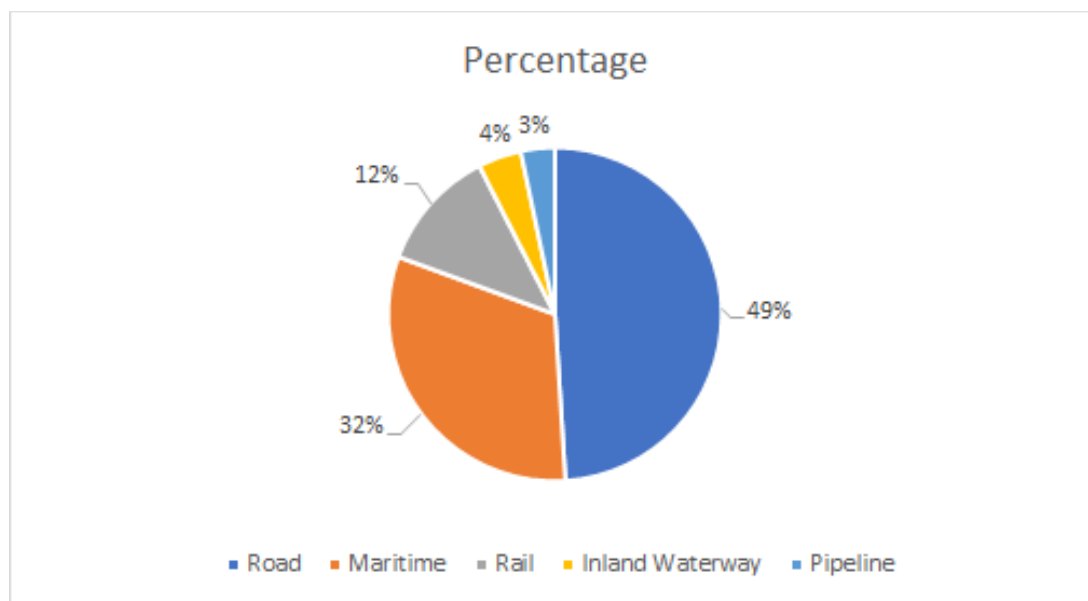


Figure 1. The division of total freight transportation in Europe by mode (Ec.europa.eu., 2016).

## 1.2 Maritime transportation and construction logistics in Sweden

Sweden has the longest coast in the EU, and several ports spread all along the coast. Even though Sweden has large amounts of suitable waterways, the goods volumes are concentrated on the main sea-ports in Gothenburg and Helsingborg. Garberg (2016) states in an official report that the capacity for inland waterway transport in Sweden today is massively under-utilized. The waterway passages around Värnern, Göta älv, and Mälaren are barely utilized, and there is no feeder-traffic between the sea-ports along the coast (Garberg, 2016). Given all this, the fact that a country such as Sweden, with an outspoken goal to be at the forefront of sustainability work, has close to none internal waterway



utilization is quite contradictory. For example, Sweden aims to be fossil fuel free in 2045, as the first country among the developed countries in the world (Regeringskansliet, 2018). In areas such as construction logistics, where the goods are usually of low value, high volume, and heavy with specific shapes, waterway transportation would naturally be a possibility.

There are several areas in Sweden under heavy construction at the moment. For example, the area around and in central Gothenburg on Sweden's west coast is currently facing one of its largest construction reformations ever. Vital areas in the center are being reconstructed to house a new public transportation system and new apartment buildings. According to Sveriges Byggindustrier (2010), around 100,000 deliveries are required for a large construction project over a 12-18 months period and in Sweden one-third of the 79,000 heavy-vehicle-fleet are transporting materials to and from construction sites. Given the already heavy congestion on the roads in and around the city, the planned construction projects will have difficulties to get materials in a fashioned manner. Therefore, it is of interest to examine the possibility of moving construction freight transportation from road to maritime transportation.

### 1.3 Trend towards sustainable transportation

With the increasing sustainability awareness in the world, not only economic factors are on the agenda, but the environmental concerns are high as well (StadieSeifi 2013). However, the pressure is put on all industries to improve their performance and reduce their impact all through their supply chain (Sheu et al., 2004). According to Bloemhof et al. (2011), the impact of the transportation industry on the environment is increasing. They argue that the sustainability of transportation modes is an upcoming issue. The European transport white paper (2011) indicates modal shifts from road and air to rail and maritime as crucial factors of sustainable transport systems. However, recent reports (Gudmundsson, H. et al., 2016) show that very little progress has been made in this area.

### 1.4 Purpose

The purpose of the thesis is to investigate the feasibility of a modal shift for construction material from road to waterway transportation in Sweden. This is performed by examining cases where such a modal change has been carried out or planned.

### 1.5 Problem formulation and research questions

In order to evaluate the possibility of a modal shift in the construction industry, it is of high importance to identify barriers and drivers for different actors. Therefore, the first and second research questions focus on the identification of these. The research questions also allow for a comparison between relevant literature and empirical data. In addition, it establishes a background and provides context for the third research question.

RQ1: What are the main drivers for a large-scale modal shift from road transportation to maritime transportation for construction material transports?

RQ2: What are the main barriers for a large-scale modal shift from road transportation to maritime transportation for construction material transports?

The third research question focuses on how to either support and heighten drivers or mitigate barriers. It compares the results and literature, providing further opportunities for analysis. It is also constructed to propose solutions on issues identified by the respondents and the frame of reference.

RQ3: How can these barriers be overcome, and drivers be accentuated?

## 1.6 Scope and limitations

The thesis will be limited to freight transportation change from road to maritime transportation and not include air freight or rail transportation. This is motivated by the fact that road transportation is by far the most utilized mode of transportation in the construction industry. Generally, it is also connected to a considerably more significant environmental impact compared to rail and maritime transportation. The focus on a modal shift to maritime transportation was based on the geographical location of several large construction projects in Sweden, in the proximity of waterways, and the under-utilization of Swedish waterways..

When the selection of scope is made in terms of geographical area from which cases are gathered, there are several things worth considering. The area selected in this study is partly limited to receivers of goods in Sweden to narrow down the possible cases. Also, this is done in order to analyze cases with the same laws, regulations, and political prerequisites in a structured and relevant manner. Further on, it is also due to assume that they, in some aspect, have a equal probability of success, given that the physical barriers are similar.

One aspect of the study which was discarded was the quantification of the costs, transportation distances, volumes being transported, and specific properties of the goods. Regarding this, the quantification of different components was ignored due to the selection of data gathering method being interviews. For the quantification of the cost, a more suitable method would be to perform a quantitative study, performed with questionnaires sent out to suitable key employees at different organizations involved in the freight transportation industry. The purpose of the paper also motivated to investigate barriers and drivers as perceived by different stakeholders in the industry; therefore, interviews were deemed more suitable for the data collection process. Specific calculations of the cost were deemed irrelevant in this aspect since a qualitative comparison between road, and maritime transportation is the purpose.

## 2. Frame of reference

*This section of the thesis will give an overview of the literature within the areas of study. Definitions and descriptions of the main subjects within waterway transportation and construction logistics are included as well as drivers and barriers of a modal shift from road to waterway transportation. The literature outlines a base for categorization within drivers and barriers.*

### 2.1 Maritime transportation

Maritime transportation has been the primary modal choice for trading between countries and regions (Kristiansen, 2004). According to the EU, 90% of the EU countries external freight is handled by maritime transport, and 40% of the internal freight (European Commission, 2014).

There are four typical actors in a transport chain based on maritime transportation (Garberg, 2016) (see Figure 2). Firstly, there is the owner of the cargo, which means either the customer or supplier of it — secondly, the transporter who performs the actual transport. Thirdly, the forwarding agent, who mediates and organizes the transport (i.e., not owning the vessel). Fourth and finally, the port or terminal operatives whose task is to load and unload between different modes of transport.

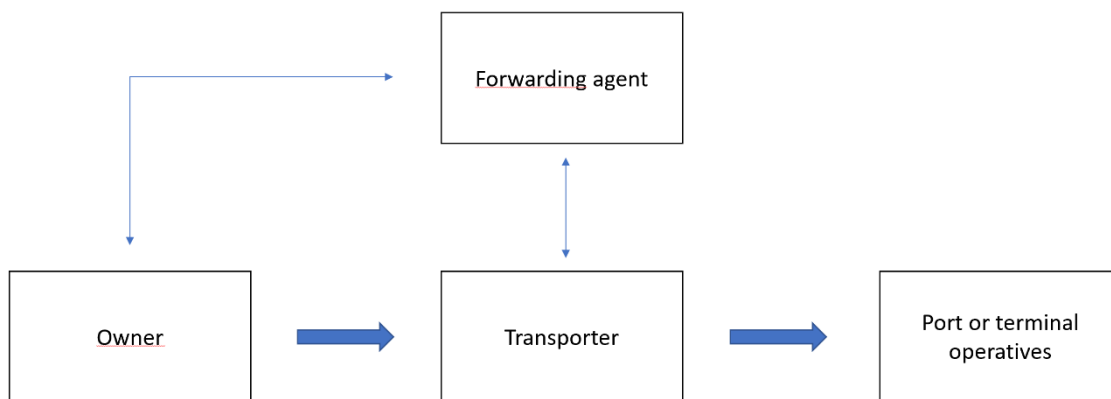


Figure 2. A figure showing the four actors in a maritime transportation chain explained by Garberg (2016). The smaller arrows indicate information flows while the thicker arrows indicate physical flows.

According to Lowe (2005), there are four different categories when analyzing shipping of cargo, i.e., maritime transportation not including passengers, only goods:

- Inland waterway transportation, transportation on the inland waterway of a country
- Coastal shipping, which is shipping along national coasts
- Short-sea shipping, maritime transportation over relatively small distances, e.g., between ports in different countries in the EU
- Deep-sea shipping, intercontinental, international shipping

#### 2.1.1 Short-sea and coastal shipping

Lowe (2005) defines coastal shipping as "coast-to-coast national shipping" and short sea shipping as "transport between the United Kingdom (UK) and continental Europe." However, several definitions could be identified from different sources. In his analysis, Lowe (2005) bundles these concepts together. Since both concepts are technically shipping over short seas, they will further be handled as one concept in this paper, called short sea shipping (SSS).

SSS is a broad concept. It is far from easy to define, and studies have different definitions (Peeters et al., 1995). It is; therefore, some authors choose to define SSS by what it is not (Paixão & Marlow, 2002).

Marlow (1997) explained the complexity by stating that SSS can involve different ships, from innovative to conventional, handling different cargo with a variety of techniques, ports, information systems, and networks. These SSS vessels and their functions are even more complicated when studied from an engineering, logistic, economic or marketing regulatory viewpoint. However, this could be a reflection of the complex nature of the European trade market. Furthermore, while several authors argue that SSS is a tramp shipping activity due to its role in the movement of dry and liquid bulk cargoes, even though scheduled operations are performed by lift-on-lift-off (Lo-Lo) and roll-on-roll-off (RO-RO) ships (Linde, 1993), other authors choose to go deeper for more accurate definitions.

#### 2.1.2 Inland waterway transportation

Inland water is defined by Merriam-webster dictionary as "any of the waters (as lakes, canals, rivers, watercourses, inlets, and bays) within the territory of a state as contrasted with the open seas or marginal waters bordering another state subject to various sovereign rights of the bordering state." Waterway transportation is one of the oldest modes of transportation, dating further back than either road, rail, or air transportation (Wiegman & Konings, 2017). Inland waterways were a widely used mode of transportation since the rivers formed natural, fast and safe transportation of passengers and goods. However, when road networks developed, and the railway was introduced, these modes challenged waterway transportation.

Wiegman & Konings (2017) describes the development in the last decades when road transportation has become increasingly popular, and rail and waterway transportation has declined. Wiegman & Konings (2017) also presents statistics that shows that inland waterway transportation declined in Euro-28 between 1995 and 2013 from 7% to 6% of the total modal share in freight transport performance in tonne-kilometers, despite that The European transport white paper (2011) states that a modal shift from road and rail to maritime transport is necessary. In order to reduce emissions and congestion, it has become part of EU-policy to promote inland waterway transportation, which is considered by far the cleaner mode of transportation (European Commission, 2014). The trend, however, can also be observed in other parts of the world. In the USA, inland waterways share of the modal split have reduced from 8,5% in 1990 to 5,8% in 2014 (European Union, 2017).

#### 2.1.3 Ships and vessels

Lumsden (2007) lists the different types of ships preferred depending on what type of cargo which is to be carried. There are general cargo ships, used to handle unitized cargo. These are divided into horizontally-operating ships (RoRo-ships: Roll on Roll off) and vertically-operating ships (LoLo-ships: Lift on Lift off), depending on which method is used to handle the cargo. Other types include container ships for containerized cargo, car carriers and ferries and passenger ships. For large volumes, there are bulk ships for liquid and dry cargo and tankers for liquid cargo. Examples of specialized types of ships are barges and river ships. Barges result in low cost since the loading space units are separated and carried by one stern (a push barge). Barges are characterized by the need for being tugged or towed by other vessels (Marine Insight, 2016). The bottom of a barge is flat-shaped in order to increase the capacity to carry cargo. The usage of barges is presently most consisting of dry bulk cargo barges and barges carrying liquid cargo.

### 2.2 Road transportation

The Economic Times (2016) defines road transportation as: "Road transport means transportation of goods and personnel from one place to the other on roads. A road is a route between two destinations, which has been either paved or worked on to enable transportation by way of motorized and non-motorised carriages."

Van Schijndel and Dinwoodie (2000) describe how road transportation development was favored in the 1980s by the technological and economic development. The change from bulk goods being transported to semi-finished and finalized products favored the use of road instead of the previously more common water and rail freight transportation mode. Further, it is explained how road transportation is favored when the parcel size is reduced, more fragmented flows liberalized regime, meaning it does not need to stick to a railway or stay on the water.

Lumsden (2007) states that the increase in road transports the last decades cannot continue. The characteristics of roads do not allow vehicles with high enough capacity to gain substantial economic benefits. Speed, weight, and size are regulated in Sweden which controls this. However, the demand for fast, efficient, and flexible transportation is what drove this development and remains high (ibid.).

### 2.3 Construction logistics

Vrijhoef and Koskela (2000) explain the characteristics of a construction supply chain by dividing it into three elements. First, the fact that the whole chain is centered around the "product," compared to traditional manufacturing where there are multiple products. The second element consists of construction, creating temporary supply chains. When the construction is completed, the chain ceases to exist, and a new one requires to be established for the next construction. Another way of phrasing it is that construction is a project-based industry, which affects the logistics to a large extent. Finally, the construction supply chain is typically make-to-order, which mean that multiple unique products are being used in each construction.

A significant issue in construction logistics is timely material deliveries when scheduling is performed short-term. There has not been much research in this area or regarding construction logistics overall. However, Ala-Risku and Karkkainen (2006) find a possible solution to this problem, consisting of two parts. First, a tracking-based approach for increasing transparency regarding inventories is introduced. Secondly, a model for pro-active deliveries of materials for specific project tasks is established. These can be used to mitigate costs and enable timely deliveries.

Another issue is to determine what KPIs are relevant to use to measure and compare the performance of logistics in construction. An interesting finding in a study made by Ying, Tookey, and Seadon (2018) is that vehicle movement could be a valid KPI for construction logistics since it links supply logistics and construction site logistics. Hence, both vehicles removing waste at the site and delivering material would be accounted for.

Vrijhoef and Koskela (2000) argue that supply chain management has four significant roles in construction logistics that need to be acknowledged. The first thing to remember is that the focus is on reducing costs and duration of site activities. In the case of the construction site, they are the insurance of dependable material flows and labor so that there are no disruptions in the workflow. They claim that this can be achieved through a relationship focus between the supplier and the site. Secondly, Vrijhoef and Koskela (2000) write that the focus should be on the supply chain itself, the goal should be to reduce costs, mainly those costs related to logistics, inventory and lead time. Thirdly, they argue that the focus needs to be on the transfer of activities from the actual production site to earlier stages of the supply chain. They claim that this could be in order to avoid some of the inferior conditions that usually exist on a construction site and to achieve alignment between activities, otherwise not possible due to construction site technical dependencies. The goal with this focus is once again to reduce costs and duration in the logistical chain. The fourth and final focus of SCM in construction Vrijhoef and Koskela (2000) identifies as the integration of management and improvement of the supply chain and production at the site. They believe that this would require the construction to be absorbed by the SCM.

## 2.4 Sustainable development

One of the prerequisites of the thesis was to examine whether or not it is plausible to use maritime transportation as a means of transportation for construction materials. This is of importance since the modal change will not be feasible if not economically sustainable, and if not more environmentally friendly and socially stable, there is no apparent motive for change.

At the moment, construction processes in Sweden release around 10 million tons of carbon dioxide equivalents. Four million of these are from housing projects, and 6 million tons are from civil engineering projects. Ten million tons is the same as the emission per year from all private cars in Sweden (IVA & Sveriges Byggindustrier, 2014).

The acknowledgment that companies needed to focus on more than just their economic success is nothing new. The idea and introduction of the triple bottom line (TBL) by Elkington (1997) was among the first in this area. Elkington presented and argued why companies should not only focus on economic success factors but also focus on environmental and social aspects. The model builds on two prerequisites, according to Robins (2006). Namely, that the company or organization follow any laws and legislation in countries where they reside and that companies who aim to apply the TBL concept have some self-inflicted higher moral responsibility, which requires them to act more responsible than any legislation forces them to.

Robins (2006) also writes that the goal of TBL is "sustainable development" or to achieve sustainability; however, he continues to argue that there are several hundred definitions of sustainability meaning that what TBLs the purpose of TBL as he describes it is hard to define. However, Jamali (2006) gives explanations of the three pillars of TBL sufficient enough for this report. He explains that the economic dimension refers to the financial stability of the organization, its competitiveness, market and job creation, and long-term profitability. The focus is mainly on generating value rather than just financial results. Jamali (2006) continues to explain the environmental dimension as the organization's impact on all living and non-living entities, including ecosystems, air, water, and land. He continues to argue that the environmental dimension is about more than just following the laws that organizations abide under; it is about the organizational approach, which means how the organization operates, how its products are constructed, how the company works with waste elimination etcetera.

The social dimension in the triple bottom line concept is related to how an organization impacts the social systems it operates within. It considers the expectations different groups has on the organization, the expectations from stakeholders, both internal and external and it also incorporates issues from the community that relates to the company, the public health, the education, the skills, the public controversies, etcetera — related to the company (Jamali, 2006).

## 2.5 Drivers modal shift

*In this chapter, the drivers of performing a modal shift from road to waterway transportation, according to current literature are identified and explained. Categories are constructed based on the findings.*

### 2.5.1 Laws and regulations

Several drivers for a modal shift from road to maritime transport are connected to barriers related to laws and regulations for road transport. In multiple Swedish cities, e.g., Gothenburg, there are low emission zones and road tolls (EU, 2015).

There are also so-called bearing regulations in several Swedish cities. Bearing regulations decide how heavy vehicles can be on a specific road. According to the traffic regulations from 1998, there are four

different bearing classes on Swedish roads, regulating how heavy trucks can be loaded depending on their size and measurements. This naturally imposes restrictions when transporting heavy cargo such as concrete etcetera by road.

In Sweden's two largest cities, Stockholm and Gothenburg, all vehicles must pay congestion tax during day time (Transportstyrelsen, 2014), which applies for vehicles registered both in Sweden and abroad. There are also bridge tolls on bridges in Motala and Sundsvall. This tax and toll naturally pose a disadvantage for road transportation in Sweden.

In order to stimulate the modal shift from road to maritime transportation, the Swedish government installed a bonus system called Ekobonus (Trafikverket, 2018b). For the period 2018-2020, 150 million SEK was dedicated to the budget for the bonus. The bonus was aimed at shipping companies, intended to reduce emissions and congestion from road transportation by stimulating new projects involving maritime transportation. In 2018, two companies received Ekobonus, approximately 8 million SEK each.

#### 2.5.2 Financial

Baird (2007) points out that while roadways and railways are usually funded by the public sector, the same cannot be said for the seaway infrastructure. This, together with that fact that roadways often are free of charge to use, Baird (2007) argues, is the reason why road transportation is the preferred over rail and water. However, The European Commission (2014) on the other hand states that compared to road, rail, and air transportation, maritime is very competitive regarding price, which is considered the main reason for its popularity.

Baird (2007) mentions a distinctive characteristic of maritime transportation as being the ability to increase capacity when necessary efficiently. The only thing required is additional ships or usage of a larger vehicle. If faster deliveries are required a simple change to a faster ship model will be sufficient to solve the issue when compared to road or railway transportation, where this either would mean increased congestion or a substantial increase in cost.

Garberg (2016) compare the cost (in Swedish kronor, SEK) of transporting one ton of cargo between rail, road, and maritime transportation. The result can be viewed below in Table 1. Garberg also states that maritime transportation over short distances increase the relative cost since there are several "firm" costs such as port fees etcetera. These do not decrease along with the distance but increase the cost per ton transported compared to road and rail. Garberg concludes that maritime transportation is a cost-efficient mode of transportation, especially when transporting large volumes of cargo over long distances. This is supported by Lumsden (2007), who claims that due to the large loading capacity, transports by sea results in general always in lower underway cost than any other mode of transportation.

*Table 1. The cost of transporting one ton of cargo by different modes of transportation, according to Garberg (2016).*

Mode of transportation	Cost per tonne-kilometer (SEK)
Maritime	0,03 – 1,61
Rail	0,2 – 1,62
Road	1,0 – 43,9

In a report, Garberg (2016) performs five case studies where transport solutions by maritime transport are examined and compared to road and rail. The case studies include a situation where both sender and receiver are situated in Sweden, as well as a scenario where cargo is sent from Sweden to German ports. One case study also included road transportation as part of the solution. The conclusion from these studies is in line with the current literature, meaning that maritime transport is increasingly cost-efficient over longer distances. However, Garberg also presents statistics illustrating the shares of cost for maritime transportation on average in the five cases. The cost related to the vessel used and the inherent costs of using a vessel on waterways constituted 42% of the cost, while cost related to using ports constituted 51% of the costs. The last 7% of the cost was related to using infrastructure, mainly consisting of fees.

### 2.5.3. Infrastructure

An inherent characteristic of road and rail transport is the network of roads or rail required to make use of the mode of transportation and the amount of traffic these can carry. Baird (2007) describes this as a limitation of the capacity of these transportation modes. However, maritime transportation does not suffer from these limitations to a nearly as large extent. The capacity of the oceans and seas could be considered extremely high in comparison, and limitation only arises in ports and on inland waterways.

Rodrigue et al. (2017) state several technical advantages of using maritime transportation, absolute advantages include the growth in mineral and energy trade, where the volumes require maritime transport. Technical improvements regarding the ability to transport different kinds of cargo (containers, natural gas, refrigerated goods) is another factor, as well as economies of scale provided by the growing size of ships. Comparative advantages include globalization, which generates the need for long-distance shipping.

Regarding IWT, Wiegman, and Konings (2017) discuss the advantages in an article. The high capacity, as well as low cost, is a prominent and important benefit, which is utilized in energy production in the USA, shipping raw materials such as coal by IWT. Seaports with waterways into the hinterland (such as the case with Gothenburg and Göta älv) can take great advantage of IWT, enabling cheap and large-scale transportation into the hinterland. A high degree of safety is another benefit of IWT and maritime transport in general compared to rail and road transport.

### 2.5.4 Environmental

From a societal viewpoint, Baird (2007) explains that the sea is free, or at least that it does not need any continuous maintenance like the road or railways. Baird (2007) also argues that while there seems to be an increasing congestion problem, the sea tends to span large and spacious area, unaffected by congestion. Further on, he mentions this as one of the main reasons for developing trading routes on the sea and develop maritime transportation. Lumsden (2007) highlights the disadvantages tied to heavy road traffic as to how roads, nature, and buildings in the proximity of a heavily trafficked roads can be negatively affected by, for example, noise and air pollution. Lowe (2005) also states that the transport sector constitutes 30% of the total energy consumption in Europe and road transport is the cause of approximately 80% of that, as well as 75% of the CO<sub>2</sub>-emissions. Other emissions caused by road transportation include carbon monoxide (CO), SO<sub>2</sub>, HC, NO<sub>x</sub>, noise, vibration, and visual intrusion (ibid.).

Maritime transportation is widely acknowledged as being an environmentally friendly mode of transportation compared to its competitors. According to the European commission's website (2018), inland waterways consume 17% energy compared to road transportation per km/ton and half of that



of rail transportation, which is a substantial decrease in energy consumption caused by material transports, if, hypothetically, a modal shift was to be made to maritime transportation with inland waterway transportation as a basis.

Garberg (2016) states in his report that maritime transport has significantly lower external effects on the environment, climate, and infrastructure compared to road transportation. However, the effects on the environment inflicted by maritime transportation are not compensated by taxes and fees to an as great extent as road transportation.

The EU Commission (2018) also highlights on their website how a modal shift of this type would reduce congestions on road networks in densely populated cities. Van Schijndel and Dinwoodie (2000) claims that the development of road transportation, i.e., how vehicles can inter-link each other and how they perform well in a system based on tightly organized schedules, is the increasing congestion on roads. They argue that congestion increases the cost and decreases the reliability of road transportation. Lowe (2005) also discusses congestion as a disadvantage of road transport, stating that it increases fuel consumption, driver costs and in itself results in increased air pollution caused by the vehicle.

Being exposed to excessive levels of noise is considered harmful. The World health organization (WHO) (2018) describes that traffic noise by itself poses a threat to the health of one-third of the population in the WHO European region. Further, one in five is considered being regularly exposed to noise levels resulting in potentially significant damage to health. Maritime transportation, in general, is regarded as a modal choice resulting in reduced noise levels compared to its competitors. In WHO's report (2018) regarding noise guidelines for the European region, rail transportation is considered the second most dominant source of environmental noise. This is an interesting fact since rail transportation is in general considered the green alternative to road transportation.

The city of Stockholm performed a study regarding noise levels when loading large quantities of rock on barges (Stockholm Stad, 2019). The study aimed at investigating if the noise levels of loading/unloading barges with large amounts of rock (which naturally could be considered a type of cargo generating noise levels higher than most cargo types) would exceed the levels considered by Sweden's environmental protection agency to be acceptable. The study showed that the barges could be loaded three times per hour without exceeding this level; however, six times per hour did not.

## 2.5.5 Summary of drivers

*Table 2. A summary of drivers identified in the frame of reference.*

<b>Laws and regulations</b>	<b>Financial</b>	<b>Infrastructure</b>	<b>Environmental</b>
<ul style="list-style-type: none"> <li>–Low emission zones</li> <li>–Road tolls</li> <li>–Bearing regulations</li> <li>–Congestion taxes</li> <li>–Governmental bonus system</li> <li>–Bridge tolls</li> </ul>	<ul style="list-style-type: none"> <li>–Price competitiveness</li> <li>–Flexibility in capacity</li> <li>–Flexibility in speed</li> <li>–Cost efficient over longer distances</li> <li>–Economies of scale</li> </ul>	<ul style="list-style-type: none"> <li>–Does not require road or rail network</li> <li>–Benefits of IWT</li> <li>–Ability to transport different types of cargo</li> </ul>	<ul style="list-style-type: none"> <li>–Sea does not require maintenance</li> <li>–Lower emissions and energy consumption</li> <li>–No increase in noise levels</li> <li>–Reduced congestion</li> </ul>

## 2.6 Barriers for a modal shift

*In this chapter, the barriers of a modal shift from road to waterway transportation are presented. Categories are constructed based on the literature.*

### 2.6.1 Laws and Regulations

Garberg (2016) thoroughly discusses issues related to laws and regulations within maritime transportation. One characteristic of maritime transport regulations is that they are often international regulations adopted on a national level. Rail and road transportation, however, is controlled by regulations on the national level or, in some cases, the EU level. Garberg continues to describe the different regulation concerning maritime transport in Sweden. There are technical standards, according to the IMO SOLAS-framework, which are international standards. All waterways surrounding Sweden are covered by SECA (Sulfur Emission Control Area), which regulates the concentration of sulfur allowed in the fuel of the vessel. There are requirements on maritime pilots, frameworks on competence, and crew size. Also, frameworks cover cabotage as well as usage of towing vessels (Garberg, 2016).

There are many fees, charges, and taxes tied to register a vessel for transportation in Sweden, further working against an increased usage of waterway transportation. All vessels longer than 12 meters and wider than 4 meters used for cargo transport require registration (Transportstyrelsen, 2017). These fees include a tax on tonnage as well as fees for shipping companies on necessary certificates etcetera. Garberg (2016) states in a report that the formal registration of such a vessel can generate costs of around 300 000 SEK (approximately 30 000€). The report also states that similar taxes and fees are considerably lower for rail and road transportation.

Garberg (2016) also points out that shipping companies and ports need to take action to increase the competitiveness of seaway transportation. He mentions several case studies where port and handling costs together make up around 50 percent of the total cost. Garberg also points out that the governmental inducted fees such as the pilotage are relatively high compared to its purpose. In the pilot studies, Garberg writes that the total governmental fees were around 7 percent of the total costs. These governmental taxes make it harder for an operator to make additional decisions to improve the entity's transport economy. However, these taxes are, according to Garberg (2016) not decisive to realize the potential of waterway transportation.

### 2.6.2 Financial

The construction industry is possibly among the most cost-oriented industries in any economy, and the logistics cost associated with construction is relatively high (Shakantu, Tookey and Bowen, 2003), which means that the construction industry is sensitive towards increases in cost in any scenario. Garbergs (2016) states that in order for inland and coastal maritime transportation to be competitive, it needs to be cost-efficient. Some scientist claim that for alternative means of transportation to road transportation (namely inland waterways, SSS or rail) to even be considered they need to lower cost by 30 to 50 percent compared to the road alternative (Baindur & Viegas, 2011). This means that both the manufacturing and maritime transportation industry are under severe economic pressure and combined the cost sensitivity should increase even further. However, the two industries should go hand in hand since the majority of components and materials used in construction is of relatively low value while at the same time being of high volume (Shakantu, Tookey & Bowen, 2003) which is precisely what maritime transportation is good at transporting. Namely carrying large amounts of goods with relatively low cost and possibly reach economies of scale.

Dubois, Hulthén, and Sundquist (2019) claim that the logistics costs are a substantial part of the entire cost in the construction industry and Lindén and Josephson (2013) continues to argue that well-planned logistics and transportation could decrease the total cost of construction by around 20 percent. However, the cost portion that comes from logistics differs depending on the goods bought. The figure below (see Figure 3) shows how much of the total purchasing price that comes from logistics costs in a study performed by Wegelius-Lehtonen (2001), where he studied supply chains in construction projects.

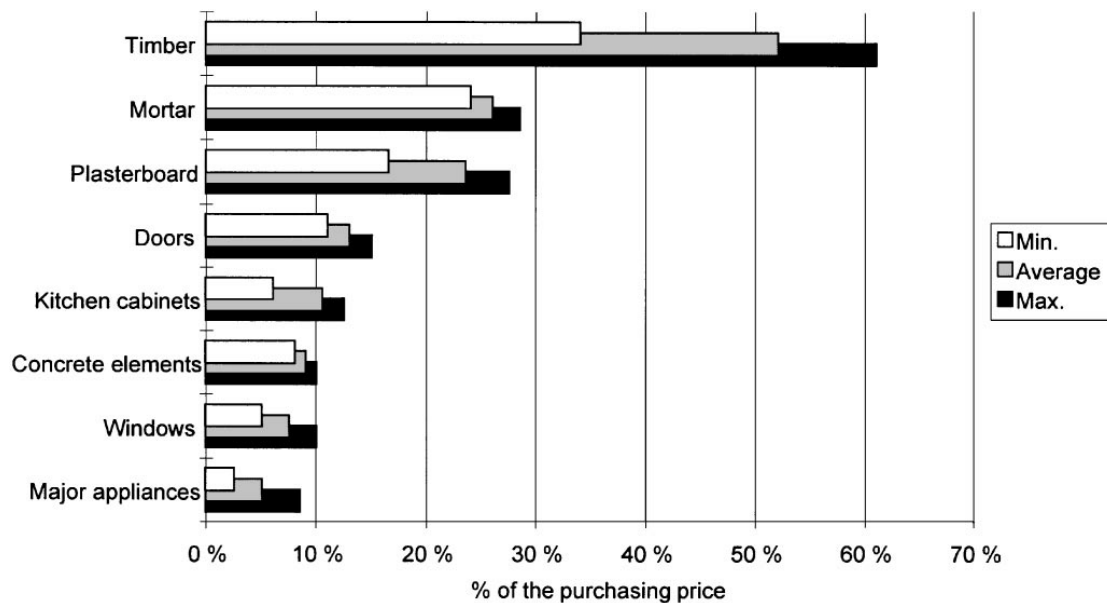


Figure 3. Differences in logistics costs within and between different material groups (Wegelius-Lehtonen, 2001).

The cheaper the product, the lower the percentage of the total purchasing price from logistics cost. Since the cost of the actual transportation in some cases can be over 60% of the total cost, at the same time as the industry is highly cost-oriented companies should want to work to decrease the logistics cost.

Baird (2007) also mentions cost as a barrier for further development of seaway transportation. He claims that the combined cost of the sea crossing, truck transportation in the beginning and the end of the journey is too expensive compared to the current door-to-door charge when land transportation is used. Lumsden (2007) agrees and argues that the limited capacity of a truck enables it to be loaded with the needs of one sole customer, which means that the buyer of transportation can adapt transport to their own needs, which means that they can adapt the routes, time of arrival, etcetera. To their specifications. Whereas if they were to consolidate their goods with other actors on a ship would force them to adapt to their business partners needs.

Garberg (2016) mentions another aspect of the harsh economic environment of maritime transportation, being the port, and handling related costs. He argues that in studies where the costs of seaway transportation were examined the results showed that these were the most significant contributors, around 50 percent of the total cost.

Both Baird (2007) and Garberg (2016) identified the regularly scheduled transportation opportunities as a factor that could enable increased usage of seaway transportation. However, in the construction industry, this is often not obtainable, since construction often is of a “one of” type of projects where more or less every project is unique (Gosling & Naim, 2009).

### 2.6.3 Infrastructural

The main resistance of the development of waterway transportation is perhaps the fact that it requires waterways for the transportation vessels to travel. However, given that there are waterways available, of sufficient shape and depth, there are other infrastructural issues that need to be addressed. For example, Garberg (2016) argues that there is a need for simpler ports for loading and unloading materials. This is increasingly important in order to realize the potential for waterway transports in the proximity of large cities and urban areas. Garberg also states that a barrier is the change of habits and traditions at transport purchasing companies. This is perhaps not a technical barrier, but it is reasonable to believe that the habit or tradition is created around technical factors. However, since this factor is barely mentioned in any other literature or stated by Garberg as an infrastructural barrier, habits, and traditions is not viewed as infrastructural barriers in this thesis.

Wiegmans and Konings (2017) also discuss the technical issues of IWT in particular, stating that it suffers from poorly extended infrastructure. The main reason for this is, according to the authors, a generally low political interest for upgrading infrastructure. This also ties into the financial issues of IWT.

Another requirement of waterway transportation is the integration between it and other modes of transportation. The ports need to be efficient in their way of handling the goods arrived by, or being transported to the vessel. Kristiansen (2004) points out that one disadvantage of waterway transportation is the integration speed between it and other modes of transportation.

### 2.6.4 Service quality

Baindur and Vieagas (2011) claim that the initial challenge for SSS to penetrate the goods transportation market, the challenge is to deliver the same service quality as road transport. The smaller quantities transported on each vessel in truck transportation means increased flexibility in terms of volumes transported when comparing road transportation to waterway transportation. Instead of having to fill an entire ship containing up to thousands of containers, each truck is limited to 1 or 2, meaning that the purchaser of the transportation has less space to fill. Lumsden (2007) mentions this type of flexibility as one of the strengths of truck transportation or looking at it from another point of view, a drawback of waterway and railway transportation.

Van Schijndel and Dinwoodie (2000) mentions that the flexibility road transport provides suits manufacturers who base their production systems on integrated logistical movements of goods and finished products on a tight schedule. These manufacturers often inter-link the arrival and departure of each vehicle and are thus reliant on a flexible means of transportation. Flexibility is also what Martell, Martínez, and Martínez de Oses (2013) claim, together with travel time, as being the main competitive advantages road transportation has towards other means of transportation. Kristiansen (2004) also discusses the downsides with maritime transportation, stating that it, in general, results in longer lead times as well as congestion in ports.

Lumsden (2007) mentions safety as an advantage of road transportation compared to other means of transportation (waterway and railway), because a relatively small quantity is transported in each vehicle. For example, a lost truck is not as catastrophic as a lost container ship or oil tanker. Further on Lumsden (2007) also points out that a truck driver travels with the goods from start to finish and the transported goods are relatively safe regarding goods comfort, avoidance of theft, avoidance of loss and damages. Lumsden also points out reliability as an advantage of road transport, since the driver accompanies the cargo. Service, in general, is another advantage since the presence of a driver creates a possibility to solve local problems the buyer of the transportation might have (ibid.).

Regarding IWT, it suffers from the same disadvantages as other types of maritime transportation. Wiegman and Konings (2017) state that flexibility is typically one of these. Garberg (2016) describes how IWT in Sweden has had difficulties competing due to long lead times, lack of flexibility, and frequency, which results in poor performance, especially when shipping lower quantities of cargo. Not having materials on site when required is considered to be one of the most common causes of delays in construction (Arditi et al., 1985; Abdul-Rahman and Alidrisi, 1994; Ibn-Homaid, 2002). In order to mitigate this, the general rule is to adapt the material flow and focus on small lot sizes, combined with reduced inventories and frequent deliveries (Sobotka, 2000; Shmanske, 2003) while at the same time ensuring that the production is continuously working, without having to stop because of material shortage. In order to achieve this, the manufacturing industry has adopted the Just-in-time (JIT) concept (Polat & Arditi, 2004). The idea of JIT is to deliver materials or products, just when they are needed and reducing inventories (Pheng & Hui, 1999) and eliminating any waste related to the keeping of inventories.

To implement JIT in construction continuous flow of materials is a requirement, the goods need to arrive in small batches, and there is a need for the transportation vessel to be fast and flexible. Thus the usage of the seaways as a mean of transportation is prohibited, due to the longer transport times, related to the slow speed of the vessels (Kristiansen, 2004). However, JIT is attractive for organizations involved in the construction industry. JIT is not only a mean improve material flow, Polat & Arditi (2004) also claims that it decreases overall costs and reduces the duration of construction projects. However, they also point out that while JIT helps organizations to reduce their inventory, it is of importance to lose the benefits of having inventory on hand, such as reaching economies of scale.

#### 2.6.5 Administrative

Garberg (2016) concludes that maritime transportation requires a significantly higher amount of administration work compared to rail and road transportation. While road transportation only requires customs documents and a bill of lading, there are multiple documents required when handling cargo in maritime transportation, especially in ports.

#### 2.6.6 Summary of barriers

*Table 3. A summary of barriers identified in the frame of reference*

<b>Laws and regulations</b>	<b>Financial</b>	<b>Infrastructure</b>	<b>Service quality</b>	<b>Administrative</b>
<ul style="list-style-type: none"> <li>–International regulations (SECA)</li> <li>–Fees, charges and taxes</li> <li>–Port and handling costs</li> </ul>	<ul style="list-style-type: none"> <li>–Construction industry cost sensitive</li> <li>–Expensive compared to road transportation</li> </ul>	<ul style="list-style-type: none"> <li>–Waterways required</li> <li>–Loading/ unloading complicated process</li> <li>–Poorly extended infrastructure</li> <li>–Low political interest for upgrading infrastructure</li> <li>–Low integration speed with other modes of transportation</li> </ul>	<ul style="list-style-type: none"> <li>–Lack of flexibility compared to road</li> <li>–Longer lead times</li> <li>–Lower safety per transport</li> <li>–Lower service level than road</li> </ul>	<ul style="list-style-type: none"> <li>–Multiple documents required</li> </ul>

### 3. Methodology

*In this chapter, the methodology of the thesis is outlined. Firstly, the research strategy and design are explained, followed by the frame of reference, data collection, and finally, the analysis.*

#### 3.1 Research strategy and design

In general, a systematic combination, based on the abductive logic, described by Dubois and Gadde (2002), is used to address the purpose of the thesis. This means combining the inductive and deductive method, a combination of theory and empirical data in order to understand both parts. In their article, Dubois and Gadde (2002) describe how the empirical data, the frame of reference, and case study evolve simultaneously. Hence, the thesis will form a Frame of reference, collect empirical data, and examine specific cases.

A qualitative research method is used for the entire process of creating this thesis. The main reason behind this is that this thesis aims at examining a situation, analyzing it and draw conclusions without manipulating it. According to Walle (2015), these are typical features of qualitative, or naturalistic, research. Qualitative studies are also able to produce a wide range of results, with varying degrees of detail (Jemielniak and Ciesielska, 2018). Further, Walle (2015) describes the standard steps marking qualitative research; determining goals, performing a literature review, and gathering data.

#### 3.2 Frame of reference

The initial stage of the project is to establish a frame of reference, where relevant articles related to, maritime transportation, road transportation, construction material logistics, is read, summarized, and reviewed. These form a knowledge base of the subject and is used to build the case, construct interview questions, and later on used as background for the paper. The Frame of reference is used as the basis of the discussion and analysis. Current literature is be prioritized, as well as similar studies and studies from the geographical area.

#### 3.3 Data collection

Data is collected via interviews with representatives from affected stakeholders in the cases which are examined. Examples of these are representatives from the affected ports, carriers, governmental agencies, and experts within the relevant subjects, such as maritime transportation and construction logistics. The interviews are performed in a semi-structured manner, giving the possibility to lead the interviewee towards the direction intended if he or she is starting to get sidetracked (Walle, 2015). The main reason behind this approach is the fact that specific answers regarding construction logistics on waterways are sought, but at simultaneously allow freedom to the interviewee in order to receive as truthful answers as possible. It is important to not steer the interviews towards the categories identified in the frame of reference, in order to be able to identify barriers and drivers not yet covered by the literature.

A standard interview form is constructed (see Table 4), with an opportunity for individual questions for each specific interview. At least two interviews from representatives from different stakeholders are conducted for each case in order to gain at least two viewpoints independent from one another regarding factors such as commercial interests. An objective is to obtain multiple viewpoints from each case and thereby map drivers and barriers from different actors as well, not only different cases. Thereby an analysis of drivers and barriers in different cases and by corresponding actors in different cases is possible. Focus is put on interviewing one spokesperson from the public sector in each case, one from a construction company and one from a shipping company in each case, since these are the directly connected actors in the transportation. Suppliers of construction material are excluded, partly for being unidentified in several cases, as well as being considered of low importance when selecting the mode of transportation. Since these in all examined cases are likely not situated in Sweden,

suppliers are not bound by Swedish regulations except when arranging transports to Sweden, and those regulations would thereby be tied to the customer, i.e., the construction company, as well as the public sector and shipper. Experts independent from stakeholders in the different cases are also interviewed, in order to establish a holistic and objective view of the drivers and barriers.

*Table 4. A table is depicting the driver and barrier categories used.*

<b>Drivers</b>	<b>Barriers</b>
Laws and Regulations	Laws and Regulations
Financial	Financial
Infrastructure	Infrastructure
Environmental	Service Quality
	Administrative
	Other

### 3.3.1 Case selection

The five cases are chosen based on a number of characteristics. Cases are constrained to be performed in the present time in Sweden since laws, regulations, and environmental factors have changed significantly. It is also deemed interesting to examine cases where a modal shift has been planned but not executed in order to identify significant barriers. Under ideal conditions, both success stories and not executed cases are examined. However, research shows maritime transportation of construction material in Sweden in recent years is highly unusual, especially in cases where road transportation was a viable option as well. The Slussen-case is an example where construction material is supplied by maritime transportation. However, no other modal option is feasible due to the characteristics of the cargo. This case is examined nonetheless, due to the regulatory circumstances (explained in chapter 4). In addition, cases in the largest Swedish cities, as well as minor ones, are both considered attractive, since the conditions differ in some regards, e.g., the level of congestion.

In total, 18 interviews are conducted. This is considered a suitable number of respondents when performing a qualitative study based on interviews, the span being 15-20, according to Latham (2014). This naturally leads to five cases considered suitable, since three actors in each case and some experts is the target to interview. One of the interviewees, the goods strategist, is the representative of the public sector in two cases since both are situated in Stockholm. In these cases, no construction company was able to participate, and the Slussen-case is considered mainly interesting from a public sector-perspective, since the cargo is one of a kind, forcing maritime transportation and will be transported with a single transport. Thereby, the regulatory perspective is considered relevant but not the perspectives of the construction company or shipper, since these have no choice regarding the arrangement of the transports. In the Stockholm bypass project-case, no suitable spokesperson for the construction company was available for interview in the necessary window of time of this thesis.

### 3.4 Analysis

Data collected is summarized and filed, which makes it easier to draw conclusions and find connections between the answers provided by the interviewees. The answers are further analyzed in depth. Afterward, interviews are complemented by and compared to the frame of reference. The comparisons are formed into the discussion and conclusion part of the paper. In the analysis, the drivers and barriers are analyzed together instead of separated, as in previous chapters, in order to compare them and be able to draw conclusions on the relative importance of drivers/barriers in each category. Further, the cases that were examined are compared in order to consider the contextual factor of the answers provided by the respondents. The answers are also analyzed based on what

actors the respondents represent and what role he or she holds. This is performed in order to compare similar actors in different cases and detect patterns in the answers. Finally, the recommendations of the authors based on the analysis is provided.



## 4. Case studies

*In this chapter, the different cases are presented and explained, at the end of the chapter, a short summary is presented in the form of a table (see Table 3).*

### 4.1 Uddevalla (Gothenburg)

Uddevalla Hamnterminal is a seaport situated in Uddevalla on the west coast of Sweden, approximately 80km north of Gothenburg. The port handles approximately 1,1 million tons of goods per year and 293 vessels (Uddevalla-hamn.se., 2017). During an interview with the marketing manager of Uddevalla Hamnterminal, he described how there is a large available capacity for loading/unloading and storing goods in the Uddevalla port. Approximately 30 000m<sup>2</sup> is currently available for storing goods, e.g., construction material.

The Uddevalla case is a hypothetical case, based on a project which was carefully planned and tested but not fully executed. The marketing director (2019) describes the case in an interview, naming the Port of Uddevalla as the initiator and naming different construction companies together with the City of Gothenburg as involved partners. During the next 30 years, a significant number of constructions will take place in central Gothenburg. The goal is to build 25 000 new apartments and 45 000 new workplaces over the next 30 years in the central area, on both sides of the river Göta Älv (Alvstaden.goteborg.se., 2016), which will naturally create a massive flow of construction material to and within the city of Gothenburg. The marketing director (2019) describes how the foundation of many of these structures includes a large number of concrete masonry units.

An example of this is the block called Platinan constructed by PEAB and will be finished approximately 2021 (Vasakronan, 2016). For this construction, 40 000 tons of concrete masonry units will be required. That will mean approximately 2 200 trucks with material for only this new block. All truck transportation will result in extensive emissions and congestion.

The Uddevalla case is an alternative transport solution for concrete masonry units transported by truck from the Baltics (The marketing director, 2016). The main set-up consists of shipping the material in bulk by seaway transportation to quays in Gothenburg instead of a truck on a ferry. Instead of transporting the material directly to the construction site (where space is limited), the material will be shipped, unloaded, and stored at Uddevalla hamn, as illustrated in Figure 4. From Uddevalla, barges will ship the material through inland waterways to a dock as close to the construction site as possible. The barge could be left at the dock and material be picked up whenever there is demand at the construction site. When the barge is empty, the tugging or towing vessel would return with a new, full barge and transport the empty barge back to Uddevalla.



Figure 4. A picture illustrating the proposed ship-barge solution by the port of Uddevalla. The orange depicts transports with ship and purple depicts transportation by barge. The city of Liepāja is chosen as the origin for this figure due to its strategically located port.

#### 4.2 Karlstad

Port of Karlstad is the largest port in lake Vänern in Sweden. It possesses equipment for handling oil, wood-, paper- and bioenergy products and heavy-lift shipments (Vanerhamn.se, 2019). The port also contains Vänernterminalen, which handles paper products for its customers, mainly storing, transshipment and distributing. The port of Karlstad has a 74.000 m<sup>2</sup> warehousing area, 105.000 m<sup>2</sup> outdoor storage, 3 km railway tracks and several tools to handle the incoming goods such as forklifts, Bobcat machines, and mobile cranes. They also house an icebreaker tugboat if the lake freezes during winter.

Pråmkompaniet is a company which offers maritime transportation and towing (Pramkompaniet.se, 2015). They have depots at five different locations in Sweden, including one at Skoghall, which is situated just outside Karlstad, approximately 10km. There are currently five barges of varied sizes stationed at Skoghall. Pråmkompaniet have an extensive collaboration with Sandinge Bogsering & Sjötransport, which enables them to offer towing vessels and barges with even more significant variation in size and capacity.

During an interview with the site manager from Pråmkompaniet (2019), a planned case of a modal shift with construction material from road to waterway transportation was discussed. She explained that several house construction project is planned in Björkås outside Karlstad, which is in the proximity of Klaraälven, which is connected to lake Vänern. Presently, in order to transport construction material to construction sites in and around Karlstad, the truck transports are forced to drive through the city center, resulting in considerable congestion and emissions. The planned case, initiated by the municipality in Karlstad, consists of the possibility of transporting the construction material by barges, owned by Pråmkompaniet, to the construction site (The site manager, 2019). They would also make sure to have all handling equipment stationed at the construction site. Depending on the location of the supplier, there is a possibility to use inland waterways from Gothenburg to the construction site. This case, however, is only on a planning stage and additional funds for further investigation in order to realize it.

#### 4.3 Stockholm

The city of Stockholm is expanding, with multiple construction projects on their way. For example, the city aims to build 140 000 between 2010 and 2013 and an expansion on the metro is also planned in a

project called bypass Stockholm, described in case 4.4 (Stockholm stad, 2018). Stockholm is mainly a service-based economy and its heavily reliant on imported goods. Today goods arrive by air, road, train or by waterways, but the last mile in the city center is almost always performed by truck, and in general, the truck leaves the city empty.

In the Stockholms stad report (2018), the conditions for freight transport through the inland waterways of lake Mälaren are considered to be good. However, only a few carriers are currently using it. Swedish law adopted EU-regulations in 2014, which enable the usage of barges for transportation. In the report, inland waterways are described to be a significant potential for being an essential supplement to rail and road transportation, hopefully, replace large parts of road transportation. However, investments in infrastructure are necessary, such as handling equipment and quays in strategic locations. Significant positive effects of performing this modal shift could be made, such as reduced emissions, reduced congestion, and higher energy efficiency.

#### 4.3.1 Slussen

Slussen (the sluice in English) in Stockholm is a critical traffic junction where ships, pedestrians, road, and public transport pass (Stockholm stad, 2017). After 80 years since the last reconstruction, a new restoration is taking place. With this project, the City of Stockholm, who also initiated the project, aims to make the area a more suitable meeting place as well as increasing capacity for public transportation, car traffic, pedestrian, and bicycle traffic. The reconstruction will also enable the locks to dispose of higher volumes of water (approximately five times as much), which will reduce the risk of flooding. This project is extensive, ongoing, and will take approximately nine years, include the usage of 8 000 tons of steel and the installation of the main bridge, weighing 3 500 tons, which will arrive in one piece by maritime transportation. This project is a part of a more considerable investment in the traffic infrastructure in Stockholm, and the size of the investment is 100 billion SEK (approximately 9,5 billion euro).

The vast amounts of materials being transported to the construction site and from it require a logistical solution which enables the people living and visiting the city to interact with the area surrounding the construction project sufficiently. A suitable solution to this issue, since the project is located so close to the waterfront is, according to the goods strategist at City of Stockholm (2019) to make transport materials over the waterways. She explains that the bridge is to be transported on water and the environmental coordinator (2019), at Stockholm municipality, explains that it is transported from China as a one-piece completely finalized unit. The environmental coordinator also explains that another essential part of the project is the sluice channel, imported from Denmark, as illustrated in Figure 5. The sluice channel is also shipped wholly built, with the issue that they might not have anywhere close to store it while they wait for the surrounding construction necessities to be solved. While there is an issue with the sluice storage, the bridge is to be submerged into the water directly from the vessel, which means that there is no requirement for any storage area, but it also means that it needs to arrive just in time. The project is active and will be executed in 2019.



Figure 5. A picture illustrating the current transportation solution used in the Slussen project. The orange depicts transports performed by ship; the thinner arrow depicts the transportation of the bridge from China and the thicker depicts the transport of the sluice parts from Denmark.

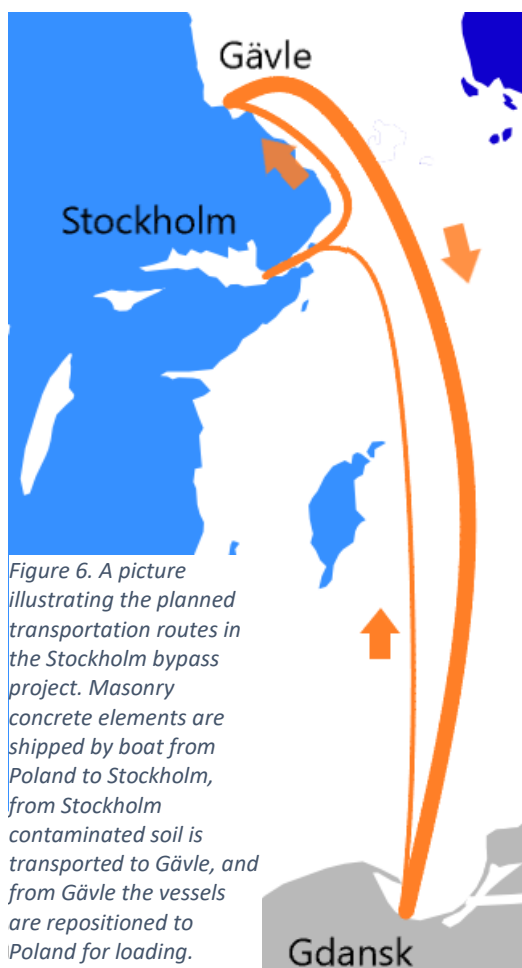


Figure 6. A picture illustrating the planned transportation routes in the Stockholm bypass project. Masonry concrete elements are shipped by boat from Poland to Stockholm, from Stockholm contaminated soil is transported to Gävle, and from Gävle the vessels are repositioned to Poland for loading.

#### 4.3.2 Stockholm bypass

The Stockholm bypass project (Förbifart Stockholm in Swedish) is a project aimed at linking the north and south parts of the city, reducing congestion on the inner city traffic (Trafikverket, 2018a). It will result in a new route for the European highway (E4) past Stockholm. The length of the route is 21km, consisting of 18km of tunnels. There will be two separate tunnel tubes at opposite directions with three lanes in each. The total cost is estimated at 3,1 billion euro.

The construction of the Stockholm bypass project will require large volumes of construction material. In an interview with a maritime consultant from Ivar Lundh & CO AB (2019), he explains how they have planned and prepared a project where they deliver concrete masonry units to the construction of the Stockholm bypass project by maritime transportation. He further explained the case in detail, where the plan is to ship contaminated soil from the construction sites in Stockholm to a processing facility in Gävle. From Gävle, the cargo ship will travel to pick up concrete masonry units from suppliers in Poland and deliver to the construction sites in Stockholm, as illustrated in Figure 6.

The goods strategist at Stockholms stad describes another initiative for maritime transportation during the Stockholm bypass project. Due to strict governmental

regulations, the residuals from explosive clearance of the path for the tunnels were transported from the construction site by cargo ships to small docks in the archipelago.

#### 4.4 Helsingborg

The city of Helsingborg is currently involved in a massive infrastructure project called H+ (Helsingborg Stad, 2016). The city of Helsingborg is estimated to grow with 40 000 inhabitants until the year 2035. The project is situated in the port area, including approximately one million square meters. In total, the project is planned to result in 5000 new offices, housing, schools, and other similar infrastructure. The project is divided into four geographical areas and will be built in separate phases. One of these areas is called Oceanhamnen and is situated in direct connection to the sea. Sustainability is a vital part of the H+-project, being an outspoken goal to achieve as sustainable progress as possible economically, environmentally, and socially.

The port of Helsingborg is one of the largest in Sweden. It has 220 employees and handles approximately 7 million tons of cargo per year (Port.helsingborg.se., 2012). It also handles about 300 000 containers of cargo, resulting in the port being the second largest container port in Sweden. Approximately 220 000 TEUs is handled via water transport and 75 000 TEUs via land transport.

The city of Helsingborg had an idea of bringing construction material for the project through the port of Helsingborg. In interviews with involved actors, the layout of the case was outlined. As the case in Uddevalla, concrete masonry units were the intended construction material to be transported from potential suppliers (no specific suppliers had been identified at this time) to the port of Helsingborg (The traffic planner, 2019, and The sales executive, 2019). The port would be responsible for unloading and storage the cargo on the quay. From there, barges (or other, similar vessels) would be loaded and shipped to the construction site. The intended construction site was Oceanhamnen in the H+ project. However, the case was never executed, since such transports could collide with the passenger ferry traffic in the port of Helsingborg. Also, the case was discussed in a late stage of the construction project, making a modal shift increasingly difficult.

#### 4.5 Summary of the cases examined

*A brief summary of all the cases examined is presented in the table below (see Table 5). It depicts the initiator, the status of the project, partners involved, contextual factors if importance, materials transported, the port of origin, end port, eventual extra ports used during the transport, the distance between supplier and buyer, the driver behind the project and the type of vessel used.*

*Table 5. Properties of the cases examined.*

	Uddevalla	Karlstad	Slussen	Stockholm bypass project	Helsingborg
Initiator	Port of Uddevalla	Municipality	City of Stockholm	City of Stockholm	City of Helsingborg
Status (and main reason for status.)	Tested but not initiated	Postponed due to lack of funds	Ongoing	Partly active	Cancelled
Partners involved	Port of Uddevalla in discussions with construction companies and city of Gothenburg	Municipality of Karlstad and Prämkompaniet	City of Stockholm	City of Stockholm, Ivar Lundh AB	City of Helsingborg, Port of Helsingborg, a nr of
Contextual important factor			One-of-a-kind cargo		Competition with passenger ferries
Material	Concrete masonry units	Unspecified	Sluice channels and a bridge	Concrete masonry units in, contaminated soil out	Concrete masonry units
Point of origin	The baltics, mainly Latvia	Unspecified	China and Denmark	Poland	Unspecified, potentially the baltics
End port	Quays in gothenburg	Temporary quays around Karlstad	Slussen	Quays in Stockholm	Oceanhamnen
Extra port for transshipment	Uddevalla	Unspecified	No	Unspecified	Port of Helsingborg
Distance	Approximately 1000-1500km	Unspecified	Unspecified	Approximately 600km	Unspecified
Main driver for initiation	Business opportunity	Convenience	Type of cargo	Requirement from municipality	Sustainability
Type of ship	Ships from baltikum to Uddevalla, barge from uddevalla to Gothenburg.	Barge	Larger vessels	Unspecified	Barge from port to construction site

## 5. Results

The results of the interviews performed are presented in this chapter. The answers are divided based on which case the interviewee was a part of. Below, Table 6 illustrates the position, company, and actor each interviewee represented.

Table 6. All interview and their responding position, company, and actor in the supply chain. The color codes represent to which case each interviewee was interviewed. Gray represents experts within maritime transportation and construction logistics.

Project	Organization	Role	Actor
Karlstad	Pråmkompaniet	Site manager	Shipper
	Karlstad municipality	Community planner	Municipality
	Lundbergs	Regional manager	Contractor
Slussen	City of Stockholm	Goods strategist	Municipality
	City of Stockholm	Environmental coordinator	Municipality
Bypass Stockholm	City of Stockholm	Goods strategist	Municipality
	Ivar Lund & CO AB	Maritime Consultant	Shipbroker & Consultant
Uddevalla	Port of Uddevalla	Marketing director	Port
	PEAB Sverige AB	KMA coordinator	Construction Company
	Traffic & Public Transp. Auth. GBG	Freight Traffic Manager	Governmental Agency
Helsingborg	City of Helsingborg	Traffic planner	Municipality
	Port of Helsingborg	Sales Executive	Port
	Serneke Bygg AB	Contract engineer	Construction Company
	City of Helsingborg	Project manager	Municipality
Experts	Gothia Marine	Naval Architect	Constultant
	Avatar Logistics AB	CEO	Shipper
	Swedish Transport Administration	Maritime Strategist	Governmental Agency
	NCC Industry	Site Manager	Construction company
	M4 Traffic	CEO	Socio-economic analysts

## 5.1 Uddevalla

In the Uddevalla case, the main driver, according to the interviewees, is road congestion. Further, there is a consensus among the KMA (quality, environment and working environment) director and the freight traffic manager (see Table 7) that the transition from road to maritime transport might lead to improved air quality. The marketing director describes in detail how construction projects in central Gothenburg will result in extensive congestion, particularly in projects in proximity to the river. In the project, Platinan which is merely a minor part of the "Älvstaden Göteborg" project, the transportation of construction material will result in approximately 2200 truck transports in the very center of the city over a 3-4 month period, according to the marketing director.

*Table 7. summary of the interviewee's opinions concerning the drivers for a modal shift from road to maritime transportation in the Uddevalla case.*

Role	Driver	Laws and Regulations	Financial	Environmental	Infrastructure
Marketing director				–Reduced congestion	
KMA coordinator	–Streets in central Gothenburg are weight restricted –Governmental bonus systems			–Reduced congestion –Reduced emissions –Lack of truckdrivers →use foreign truckers with inferior trucks concerning emission standards	–Lack of truck drivers
Freight Traffic Manager				–Reduced congestion –Reduced environmental impact	

The KMA director mentions three drivers that neither the marketing director or the freight traffic manager highlighted, namely the lack of truck drivers, national bonus systems, and load-bearing regulations on roads in central Gothenburg. She further describes the strict requirements Sweden put on its truck companies in terms of particulate emissions and raises the possibility that if the decrease of Swedish truck drivers continue the demand on foreign truckers will increase. The problem lies not supposedly with the truck drivers themselves, the KMA director explains, but the specifications of the trucks they drive, with lower standards concerning their particulate filters and emissions, which could lower the air quality. When discussing the national bonus system "Eco-Bonus" the KMA director is positive in general but points out that it is unclear at which actor it is aimed at and what type of actors can apply for it, shippers or the construction company, etcetera. Further, the KMA director highlights that while the economic side of the bonus system is a driver, the complexity and vagueness behind it results in it being confusing and hard to comprehend.

Concerning trucks traveling on roads with load-bearing regulations, The KMA director explains that this emerges from having several construction projects in the proximity to each other, congesting the roads that otherwise would be suitable for transportation of materials. This result in trucks requires to travel on otherwise weight regulated roads. She connects this with the inability of the municipality of Gothenburg to understand the current traffic situation and how it might evolve in the future. However, she also points out that this could form a situation favorable to waterway transportation, but that it is perhaps too late to make the modal transition for the current projects.

Table 8. A summary of the barriers for a modal shift from road to maritime transportation described by the interviewees in the Uddevalla-case.

Role	Barrier	Laws and Regulations	Financial	Environmental	Infrastructure	Service Quality	Administrative	Other
Marketing director			<ul style="list-style-type: none"> <li>–Require available return goods</li> <li>–Lower costs is a prerequisite for a modal switch</li> </ul>		<ul style="list-style-type: none"> <li>–Physical barriers, e.g. low bridges, lack of waterways</li> <li>–Require special cranes</li> </ul>	<ul style="list-style-type: none"> <li>–Inflexibility</li> </ul>	<ul style="list-style-type: none"> <li>–Lack of coordination between parties to reach financially sustainable volumes</li> </ul>	
KMA coordinator	<ul style="list-style-type: none"> <li>–Eco-bonus was poorly implemented</li> </ul>				<ul style="list-style-type: none"> <li>–Depth of waterways</li> <li>–Buoyancy of the water</li> <li>–Buoyancy of the quay</li> <li>–Infrastructure</li> </ul>		<ul style="list-style-type: none"> <li>–Coordination between suppliers and coordination between construction agencies</li> </ul>	<ul style="list-style-type: none"> <li>–Lack of interest from politicians</li> </ul>
Freight Traffic Manager			<ul style="list-style-type: none"> <li>–There is a lack of funds from the public sector for weight-bearing capability tests on roads and ports etcetera</li> </ul>				<ul style="list-style-type: none"> <li>–Lack of coordination between municipal instances and municipal companies</li> </ul>	<ul style="list-style-type: none"> <li>–There is no clear benefit for the private sector</li> <li>–Lack of political action</li> <li>–Lack of knowledge and competence among politicians</li> </ul>

The marketing director argues that maritime transportation needs to result in significantly lower costs than road transportation even be considered. He also highlights several financial barriers for a modal transition from road to waterway transportation, exception from the individual cost in itself. Firstly, he argues that there is a requirement for maritime transportation to have return goods; otherwise, the economic aspect of it being cheaper than the road cannot be realized. The freight traffic manager mentions that he sees a lack of funds in the public sectors. He argues that more funds could be used for weight-bearing capability investigations, which perhaps could enable more temporary quays for construction projects.

*“We received funds and performed a test in the river. It was established that this arrangement would never be financially sustainable unless we somehow had return goods from Gothenburg to Uddevalla.”*

The marketing director (2019)

All three of the interviewees seems to agree that there is a lack of political backing for a modal transition (see Table 8). The marketing director claims that politicians need to start taking action, and he mentions in the same sentence that sustainability always will be secondary for companies and that it is politicians who need to make them act sustainably. The KMA director agrees with the marketing director and adds that the idea behind Eco-Bonus is excellent, but that it is poorly executed and the system is unnecessarily hard to understand and take part in. The freight traffic manager describes that he experiences a lack of political focus on the subject. He discusses what could be the reason behind and concludes that it could partly be based on a lack of knowledge and competence within the subject among politicians. The freight traffic manager, similar to the marketing director, claims that there is no real benefit for the private sector of a modal transition and that the public sector will be required to lead companies and organizations to act more sustainable.

*“Somehow, the situation is not in phase with the development in the city. Officials have a will to improve but have yet to see the possibilities.”*

The KMA director (2019)

The marketing director and the KMA director discuss some technical barriers as well. The marketing director highlights specifically low bridges and temporary or special cranes for loading and unloading as hinders. The KMA director mentions the depth of the water, the buoyancy of the water and



buoyancy of the quay, to name a few, together with cranes and infrastructure suitable for maritime transportation.

Also worth noting is that The freight traffic manager, the marketing director, and the KMA director all three mention administrative issues as barriers for the success of the Uddevalla case (see Table 6). The marketing director states that parties in the supply chain will be required to increase the level of cooperation to reach economically sustainable levels. The freight traffic manager and the KMA director mention an increase and improvement in the quality of cooperation in more general terms as prerequisites for seaway transportation. The marketing director argues that there seems to be a lack of will from suppliers to cooperate because of pride and unwillingness to cooperate with competitors.

*“There is no clear benefit for companies to invest in maritime transportation, either the customer's needs to make demands or the government needs to take action and force them”*

The freight traffic manager (2019)

The marketing director also briefly discusses the lack of flexibility in seaway transportation as a barrier for the Uddevalla - Gothenburg concept. He describes how customers can change their requirements very late in the process with road transportation, while in the case of the generally slower maritime transportation, they have to decide in a much earlier stage and cannot correct the decision. He gives an example of how construction firms in western Sweden, who buys their concrete elements from the Baltics, can change their orders just a few days in advance when using road transportation, but if they were to use maritime transportation, they would need to make decision weeks in advance.

## 5.2 Karlstad

In table 9, it is clearly illustrated that reduced congestion and lower levels of emissions are considered critical drivers by all three interviewees. However, the site manager, representing a shipping company, also pushes for the technical advantages of maritime transportation by barge. The possibility of using the barge as additional storage space is a clear benefit, according to the site manager. Additionally, the proximity to waterways of the city center is highlighted as a critical driver, enabling smooth unloading as well as loading of possible return goods.

*Table 9. summary of the interviewee's opinions concerning the drivers for a modal shift from road to maritime transportation in the Karlstad case.*

Role	Driver	Laws and Regulations	Financial	Environmental	Infrastructure
Site manager			–Large portion of infrastructure already in place	–Reduced emissions –Reduced congestion	–Possibility of using barges for warehousing of goods
Community planner				–Reduced emissions –Reduced congestion	
Regional manager				–Reduced environmental impact	

Table 10. A summary of the barriers for a modal shift from road to maritime transportation described by the interviewees in the Uddevalla-case.

Role	Barrier	Laws and Regulations	Financial	Environmental	Infrastructure	Service Quality	Administrative	Other
Site manager			<ul style="list-style-type: none"> <li>–Will not be economically competitive compared to road</li> <li>–Lack of investments from municipality etc.</li> </ul>					
Community planner	<ul style="list-style-type: none"> <li>–You can not have specific requirements in one municipality</li> <li>–Largest obstacle is lack of clear means of control</li> </ul>				<ul style="list-style-type: none"> <li>–Lack of paved shoreline</li> <li>–Not authorized to dredge the river</li> </ul>			
Regional manager					<ul style="list-style-type: none"> <li>–Sluices and bridges creates bottlenecks</li> <li>–Require water</li> </ul>			<ul style="list-style-type: none"> <li>–Habits and prejudices prohibit innovation</li> <li>–Do not view maritime transport as a viable alternative</li> </ul>

The barriers of a modal shift have significant differences among the interviewees. While the site manager highlights the financial difficulties, the community manager, representing the municipality of Karlstad, mentions both obstacles in regulations and technical areas (see Table 10).

*“Our greatest obstacle to support an increase in maritime transportation is clear means of control. The directive from the government is to reduce the requirements on developers, which complicates our possibilities to support.”*

The community manager (2019)

The community manager (2019) also explains that municipalities can make demands in the procurement phase when they are taking bids from companies on rights to build on pieces of land. However, they cannot make demands on how the materials are transported there, and they do not have the legal right to do so. They can make demands on the emissions but cannot steer into a specific modal transportation mode.

The site manager argues that costs in short-term will not be lower by maritime transportation compared to road and a modal shift demands investments from the public sector. The regional manager, the regional manager at Lundbergs, a developer in Karlstad, described technical barriers as key, as well as adding the habitual perspective. The fact that road transportation is considered the standard mode of transportation and has been for an extended period results in maritime transportation not being considered as a viable option by transportation purchasers. Further, sluices and bridges present on the inland waterways leading to Karlstad constitute bottlenecks for vessels traveling this way.

### 5.3 Slussen

Both the environmental coordinator and the goods strategist (see Table 11) states that proximity to water is a crucial driver for the usage of maritime transportation. The environmental coordinator expanded on this, adding that there is a lack of space for storage near the construction site and suggest that barges could be used as temporary storage vessels, in addition to transporting goods.

Table 11. Summary of the interviewee's opinions concerning the drivers for a modal shift from road to maritime transportation in the Slussen case.

Role	Driver	Laws and Regulations	Financial	Environmental	Infrastructure
Goods strategist		–Streets in central Stockholm are weight restricted	–Suitable for large volumes	–Congestion issues in central Stockholm	–Construction site in the proximity of the water
Environmental coordinator					–Construction site in the proximity of the water –Lack of storing area in proximity to the construction site

The goods strategist also highlights drivers such as weight restrictions on the streets in the center of Stockholm as a driver for increased usage of waterway transportation:

*“Waterway transportation is suitable for this project since its performed just pretty much on the water. If I remember correctly; they also plan to transport the rock masses produced by the project on the water, with the motivation being in the proximity to the site. However, it could also depend on the unpractical nature of transporting large volumes of soil on trucks.”*

The goods strategist (2019)

In other words, the goods strategist highlights drivers such as the suitability of waterways for large volumes, the suitability of the transport mode when there are some limits concerning weight and space on the road network close to the construction site.

Table 12. Summary of the barriers for a modal shift from road to maritime transportation described by the interviewees in the Slussen case.

Role	Barrier	Laws and Regulations	Financial	Environmental	Infrastructure	Service Quality	Administrative	Other
Goods strategist					–Waterway transportation are neglected and loading/unloading points erased –Requires reloading		–Require reloading	–Prejudice –Habit, in modern times truck has always been the mode of choice
Environmental coordinator	–Low emission zones				–Require reloading –Infrastructure –There is shortage of space near water			

Both the goods strategist and the environmental coordinator highlights that a key barrier is a requirement for transshipment of the cargo when using maritime transportation, which is time-consuming as well as resulting in additional administration such as toll documents etcetera (see Table 12). The goods strategist also points out that loading points such as quays built next to construction projects are temporary, being a liability afterward, often requiring to be erased. The environmental coordinator, on the other hand, describes that even though Stockholm is a city surrounded by water, the space near water available for maritime transportation is quite limited and a lack of appropriate infrastructure for loading and unloading cargo. She also points out the issue of a lack of interest from politicians, meaning that they taking action could be crucial for an increase in maritime transportation.

An intriguing barrier pointed out by the goods strategist, is habitual. Similarly to the regional manager in the Karlstad case, she highlights the fact that road transportation is widely considered to be the standard mode of transportation for construction material.

## 5.4 The Stockholm bypass project

The goods strategist gives a specific driver for the Stockholm bypass project, that does not apply on the Slussen project. As previously mentioned, the Stockholm bypass project is a project initiated by the Government of Sweden while the municipality of Stockholm initiates the Slussen project. The primary motivation for the Stockholm bypass project using waterway transportation is a requirement from the government of Sweden; there was simply a constraint by the government to use maritime transportation in order to approve the project.

*Table 13. Summary of the interviewee's opinions concerning the drivers for a modal shift from road to maritime transportation in The Stockholm bypass project-case.*

Role	Driver	Laws and Regulations	Financial	Environmental	Infrastructure
Goods strategist		–Political restrictions of using maritime transportation			
Maritime Consultant			–Economies of Scale	– Reduced environmental impact –Reduced congestion	–Not affected by road congestion issues

The maritime consultant provides other drivers as to why companies and organizations should/would use waterway transportation in more general terms (see Table 13). He mentions the notion of the improved possibility to reach economies of scale, the reduced congestion on roads and the environmental impact of trucks and similar road vehicles. The maritime consultant also points out that road congestion and overall environmental impact are the main drivers for the government and governmental agencies, while they are secondary for companies. He also mentions that the possibility of limited space of specific road networks adds to the attractiveness of waterway if it exists, which is often the case in larger cities with many construction projects being performed simultaneously.

*Table 14. A summary of the barriers for a modal shift from road to maritime transportation described by the interviewees in the Stockholm bypass project-case.*

Role	Barrier	Laws and Regulations	Financial	Environmental	Infrastructure	Service Quality	Administrative	Other
Goods strategist						–Lack of JIT, inflexibility		
Maritime Consultant		–Difficult to apply for governmental bonuses	–Larger quantities required –Will not be economically competitive if there is no return goods available		–Require reloading for last mile	–Inflexibility	–Require reloading for last mile	

As previously mentioned, the maritime consultant concludes that one of the reasons companies and organizations might want to use waterway transportation is because of the possibility of reaching economies of scale. However, this fact also forces companies to fill more space, meaning that they need to ship higher volumes of goods per transport. The maritime consultant also adds that this will complicate making maritime transports financially sustainable and that it is close to a requirement to identify return cargo in order to do so.

The issue of transshipment for the last mile is also an issue that the maritime consultant highlights (see Table 14). It requires the quays to have suitable cranes and infrastructure solutions for unloading the goods from the sea vessels to trucks or similar road transportation solutions. The maritime consultant also highlighted the inflexibility of waterway transportation and received support for this statement by the goods strategist, who explained that the branch standard in construction is to use the Just-In-Time principle. Further, she stated that one of the main reasons of the unpopularity of waterway transportation within the construction industry is the fact that the ability to use a Just-In-Time is massively reduced, if not impossible in many cases.

Finally, the maritime consultant also explained the reason why he thought that the government financial aid package Ekobonus was not so widespread as it might have been. The reason, he explained,

was because it was a complicated process to apply for it. He briefly explained the process behind the initiative. The current government of Sweden at this time initiated the idea during the beginning of their term. However, the project was inactive, but 50 Million SEK was still deposited for it during the period 2018-2020. There was no date announced for when the applications were due or what they were supposed to contain.

*"Then there was no news for a while. But then suddenly they announced that they had set aside 50 million (SEK) per year during the period 2018-2020. The money was allocated to the year they announced the bonus system, not the year the project would start, which was quite strange, to be honest. Then they announced a Thursday that the latest day for the application was Tuesday the following week."*

The maritime consultant (2019)

Suddenly, on a Thursday it was announced that the applications had to be in at latest Tuesday the following week, which meant that organizations that were interested had a very narrow window of time to produce their case, motivating why they should receive the grant. The maritime consultant argues that the time given was minimal and resulted in organizations interested in the grant had to rush an application. Another issue, he explained, was that the only organizations who could apply were the shipping companies, and if there were no finished contracts between the shippers and the construction companies resulted in them being unable to apply for the grant. There was also a requirement for the applying company to prove that the transport arrangement meant increasing maritime transportation at the expense of road transportation. Also, the maritime consultant explains that the project was constrained to be unprofitable due to using maritime transportation to receive the Ekobonus grant. This meant, according to the maritime consultant, that the project had to have a negative result for the two years they were given the grant, and once they stopped receiving funds, the transport solution had to be financially sustainable. This is an issue due to the low probability that companies would invest in something that would not be financially sustainable in the long term. The maritime consultant raises the question of how shipowners and their partners are supposed to calculate if they will be profitable after two years when being unprofitable during that period.

*"It becomes a matter of assumptions and qualified guesses. The structure of the grant makes it impossible to apply feasibly. We were also denied the grant for another project due to not being able to prove that it did not increase maritime transportation at the expense of road transportation. To prove that it is at the expense of road is difficult."*

The maritime consultant (2019)

## 5.5 Helsingborg

There is a consensus between the sales executive and the contract engineer that a significant driver for a modal shift can be identified as the ability to carry higher volumes of goods and thereby gain financial advantages. The sales executive, as a representant for the port of Helsingborg and the contract engineer, representing a construction company, naturally know financial aspects of transportation. Further, a broad consensus among the interviewees can be interpreted regarding environmental drivers.

Table 15. Summary of the interviewee's opinions concerning the drivers for a modal shift from road to maritime transportation in the Helsingborg case.

Role	Driver	Laws and Regulations	Financial	Environmental	Infrastructure
Traffic planner				–Reduced congestion –Reduced emissions	–Construction sites in close proximity to water
Sales Executive			–Economies of Scale	–Reduced environmental impact –Prediction that congestion will increase as a result of road transports	–Construction sites in close proximity to the water
Contract engineer			–Usefull for larger masses	–Reduced congestion	
Project manager				–Reduced congestion	–Construction sites in close proximity to the water –Not affected by road congestion issues

All interviewees mention reduced congestion as a significant driver for a modal shift towards maritime transport. The same could be identified regarding the technical drivers (see Table 15). Three out of four interviewees consider the location of the construction project to be vital, with waterways in direct proximity.

*“From our perspective, it is purely an environmental benefit. If we were contracted to store material in the port, it is not financially beneficial to have it picked up by barge compared to road transportation. On the contrary, it could be a disadvantage since we already have relationships with road haulers.”*

The sales executive (2019)

Table 16. A summary of the barriers for a modal shift from road to maritime transportation described by the interviewees in the Helsingborg-case.

Role	Barrier	Laws and Regulations	Financial	Environmental	Infrastructure	Service Quality	Administrative	Other
Traffic planner			–Difficult to achieve economical sustainability					–Lack of knowledge among employees at municipalities regarding the benefits of maritime transportation –Lack of political empowerment
Sales Executive					–Buoyancy capacity limits capacity		–Lack of cooperation between actors –Maritime transportation require coordination among actors	
Contract engineer			–Higher costs tied to maritime transportation compared to road	–Collides with the local ferry schedule	–Requires cranes for unloading		–No established standard contract layout for maritime transportation	
Project manager	–Requires permission from port authorities, shipping companies etcetera		–Compensations costs for affected actors	–Interception with passenger transportations				–Conservative builders and politicians obstructs change

The interviewees gave considerably more significant differences in opinions regarding what barriers are essential for a modal shift. However, the traffic planner, the contract engineer, and the project manager highlight the fact that maritime transportation is considered being tied to higher costs (see Table 16). Another barrier, which naturally is very specific for this case, is the fact that a ferry line crosses the intended waterway to be used for transports to the construction project. The contract engineer and the project manager both argue that this would represent a great difficulty since the

ferry during the summer season departs every twenty minutes and is highly prioritized by the city of Helsingborg.

Further on, the project manager also explains how the permission process hinders the expansion of maritime transportation in the Helsingborg case. The permissions he refers to is regarding the interruption of the passenger transportation ferries going between Helsingborg and Helsingör, and since the city is very keen on keeping them going, he thinks it would be hard for the applications to pass.

Regarding infrastructural barriers, the sales executive explains that there is a capacity limit to how large volumes could be stored at the port. The contract engineer adds that this case would require cranes for unloading. Another barrier identified by these interviewees is administrative. Lack of coordination between actors regarding paperwork one aspect of this the sales executive highlights, together with a lack of cooperation between different actors, which he argues is crucial. The contract engineer mentions the lack of standardized contracts for maritime transportation, which exist for road transportation, and explains that this would ease the administrative barrier behind maritime transportation.

The habitual barrier is also highlighted in this case. The project manager discusses the conservatism amongst builders and politicians, stating that this is a critical barrier. Further, the traffic planner states that lack of knowledge at the municipality level and general political empowerment constitutes a hinder.

## 5.6 Experts

The naval architect argued that maritime transportation is competitive when there is a lack of space on road networks and when there is a need to transport large masses of low-value materials. The naval architect also highlighted the usefulness of seaways when there is a problem with congestion on the roads, which also was brought up by the CEO from Avatar Logistics and the maritime strategist (see Table 17). The naval architect finally claimed the usefulness of seaway transportation when a construction project is near the water.

*Table 17. Summary of the interviewee's opinions concerning the drivers for a modal shift from road to maritime transportation from experts and people in the industry not bound to any specific case.*

Role	Driver	Laws and Regulations	Financial	Environmental	Infrastructure
Naval Architect			–Suitable for large masses of low value materials	–Reduced congestion	–Lack of space –Construction site in close proximity of water
CEO			–Does not demand maintenance like road –High capacity of vessels compared to road vehicles		–Significantly lower congestion problems compared to road networks –Lack of truck drivers
Maritime Strategist			–Usefull for larger volumes	–Reduced congestion –Reduced environmental impact	
Site Manager			–Lower costs over vast distances		–Barges can be used for warehousing
CEO				–Socio-economically sustainable –Reduced emissions	–Barges can be used for warehousing

The CEO from Avatar Logistics highlighted the fact that seaways does not require maintenance and has no expiration date, when in comparison with land-based transportation modes. He also pointed out that there is a lack of truck drivers in Sweden, adding that there is a possibility to take the same load on one barge as several trucks combined.

The site manager declared the benefit of seaway transportation over long distances, and she also highlighted the economic aspect as unsustainable on shorter voyages. The site manager further on mentioned that barge could be used for warehousing, which is a benefit The CEO of M4 traffic also discussed. The maritime strategist also highlighted the environmental sustainability of seaway transportation.

*Table 18. A summary of the barriers for a modal shift from road to maritime transportation described by experts and people in the industry not bound to any specific case.*

Role	Barrier	Laws and Regulations	Financial	Environmental	Infrastructure	Service Quality	Administrative	Other
Naval Architect			<ul style="list-style-type: none"> <li>–Not economically sustainable</li> <li>–To small volumes to be competitive</li> </ul>		<ul style="list-style-type: none"> <li>–Reloading required</li> </ul>		<ul style="list-style-type: none"> <li>–Lack of JIT</li> </ul>	
CEO					<ul style="list-style-type: none"> <li>–The industry has a well established solution for land based transport</li> </ul>			<ul style="list-style-type: none"> <li>–Lack of experience among companies and municipalities</li> <li>–Lack of political action from municipalities</li> </ul>
Maritime Strategist	<ul style="list-style-type: none"> <li>–Environmentall regulations for port activities</li> </ul>				<ul style="list-style-type: none"> <li>–Quays not fit for handling goods of different characteristics</li> </ul>			<ul style="list-style-type: none"> <li>–The idea of using maritime transportation enters to late in the process</li> <li>–Maritime transportation requires planning from the procurement phase</li> </ul>
Site Manager			<ul style="list-style-type: none"> <li>–Short distances by waterways not financial sustainable</li> <li>–Requirement of reloading results in higher costs</li> <li>–Require infrastructure investments</li> </ul>				<ul style="list-style-type: none"> <li>–Require reloading if not in the proximity of waterways</li> </ul>	
CEO			<ul style="list-style-type: none"> <li>–Unclear how extra costs connected to modal transition should be divided</li> </ul>		<ul style="list-style-type: none"> <li>–Requires more space</li> </ul>			<ul style="list-style-type: none"> <li>–Sustainability is secondary</li> </ul>

The naval architect and the site manager choose to highlight the economic backside of waterway transportation. The naval architect stated that it is often too low volumes for the transport to be economically viable and the site manager that the distances usually needs to be longer for it to be sustainable and that the transshipment of the cargo from ship to truck often result in the option being too expensive. The naval architect also declared that the transshipment is an issue in terms of it being a technical barrier rather than a financial (see Table 16). The maritime strategist touched upon a similar barrier, claiming that quays often lack the required cranes and handling equipment to unload the cargo from ships. The site manager also highlighted the issue of transshipment; however, she specified and said that it was only an issue if the project was not near water. She continued and argued that a requirement for an increase in seaway transportation is infrastructure like ports, quays, and cranes.

The naval architect briefly discussed the service quality of seaway transportation as an issue, comparing it to the road. He specifically mentioned the lack of ability to use JIT as an issue for maritime transportation.

The CEO from Avatar Logistics also mentions the lack of experience among companies and municipalities as a barrier for extended usage of maritime transportation. He mentions that there already exists well-established solutions for land-based transportation solutions, and the lack of pressure from municipalities and other governmental agencies results in the maritime solution often not even being considered. The CEO from Avatar Logistics continued to argue that government agencies often say that they are in favor of extended maritime transportation tries to promote it, but minimal practical action is taken other than verbal support. The maritime strategist, on the other hand, stated that the initiative to receiving in the goods from the sea is often brought up in a late stage of the project when the transportation channels are already set up. The initiative to transport the goods by maritime transportations must to considered earlier in the process.



*"A key factor in successfully performing a modal shift is to consider the transport arrangement earlier in the process. Already in the procurement phase, requirements for maritime transportation must be made."*

The maritime strategist (2019)

The maritime strategist also highlighted the Swedish law "Miljöbalken" and how its content restricts and decides what port activities are allowed and not hinder the possible increase in port activities, he claims that it is too focused on the weight transported on the vessel.

The CEO of M4 traffic provided some previously not mentioned issues regarding the actual costs of a modal transition. He described a case where M4 Traffic was hired to calculate the socio-economic costs of a potential project, including the potential for maritime transportation (M4Traffic, 2015). The arrangement meant to transport concrete masonry units by barges from Södertälje (situated approximately 40 km southwest of Stockholm) instead of the road. Including various assumptions such as travel distance, the capacity of a barge, etcetera., the calculation was performed and resulted in the conclusion that such a modal shift would be beneficial from a socio-economic viewpoint. He presented the calculation for different governmental agencies, representants from ports and construction companies. The commitment was high among the participants, but the financial discussion swiftly became prioritized. Sustainability as a part of the cost was not considered.

The CEO of M4 traffic also highlights an issue regarding the massive loads of transported goods by maritime transport at once.

*"Another issue is that you might have to invest in larger warehousing areas. Compare one truck-load of goods, around 24 tons, with one standard vessel-load of goods, around 4000 tons. You will require additional warehousing area."*

The CEO of M4 traffic (2019)

Further, the CEO of M4 traffic argues that if the barge is chosen to a project, it could, in addition to a mean of transportation, be utilized as a temporary warehouse. However, to borrow the barge for additional time will result in a fee.

## 6. Analysis

*This chapter provides an in-depth analysis of the findings of the study, both theoretical and empirical through interviews. First, an analysis based on the identified drivers and barriers is performed, outlining the main findings of the frame of reference and the interviews, comparing these. Secondly, a comparison of the cases examined is provided in order to understand why some were executed, others planned, and some canceled. Thirdly, an analysis based on what different actors considered being the main drivers and barriers, comparing answers by corresponding actors from separate cases. Further, the authors recommend that actions within construction logistics are provided. Finally, reflections regarding the study's contribution to previous research are presented, as well as the potential for future research in the subject.*

### 6.1 Drivers and Barriers

*In this part of the analysis chapter, the findings regarding the main drivers of a modal shift are analyzed. The answers provided through interviews are compared to the Frame of reference.*

#### 6.1.1 Laws and Regulations

Concerning laws and regulations, only two of the interviewees claimed that those drivers favor the use of maritime transportation. The KMA director (2019) mentioned weight restricted roads in Gothenburg as a driver, while the goods strategist (2019) made the same argument for Stockholm. Although there seems to be a lack of literature discussing the subject on how lawmakers and government officials should promote maritime transport for construction logistics, there are laws in larger Swedish cities meant to decrease road congestion and traffic. Firstly, there are the road bearing regulations, meant to remove heavy truck traffic from the city centers. Second, for example, in Gothenburg, there are low emission zones and road tolls (EU, 2015). Lastly, there are also congestion taxes during day times in both Stockholm and Gothenburg, which is meant to reduce road transportation

Notably, in the Gothenburg case, construction projects were allowed to receive their materials via road even though they were weight restricted by the City of Gothenburg. So, in this case, what is usually considered a driver for using the waterway, stops being an issue for construction companies, who already favor truck and road. The reason waterway transportation was used in the Slussen project, according to the goods strategist (2019) could be because of its proximity to the water, and how impractical it would be to transport the cargo by road. This means that the weight regulations did not play a significant role in the modal selection; there were other drivers more crucial to the modal selection of sea vessels. The Stockholm bypass project also uses the seaways for transportation of goods, but the main motive is the demand from the Swedish government. This means that in none of the cases examined in this study, where weight regulation on roads is present, it seemed to have played a role in promoting the usage of waterways in a significant way.

As explained in section 2.5.1. Trafikverket (2018) installed a bonus system called Ekobonus during the period 2018-2020 where shippers could apply for grant money if they were to use maritime transportation instead of road transportation. The KMA director (2019) mentioned that this type of national bonus systems should be incentives for an increase in maritime transportation. However, she continues to argue that at the moment, they are not, at least not Eco-bonus. Further, she described the poor implementation of the bonus system and mentioned that aspects such as which actor was able to apply and in what purpose was unclear. The maritime consultant (2019) also highlighted this issue and explained that there was a four-day window to apply for Ekobonus, and also described the construction of the bonus system as insufficient. Worth noticing could be that both of the interviewees who mentioned this is from the private sector, while none of the government employed highlighted this. Garberg (2016), representing a governmental agency in Sweden, mentions several taxes imposed upon registration of new ships and other fees that prohibits the modal transition, in the interview he

also discusses that there are regulations in Swedish ports prohibiting ships from entering and leaving the ports. In hindsight, investing millions of SEK in a project in what some respondents explained as a poorly constructed, which resulted in two companies receiving grants of 8 million SEK each, he considered a mistake. Instead, examining old systems that seems to prohibit maritime transportation and instead favor road, could be a possible solution to nurture a modal transition from road transportation to maritime transportation.

The community manager (2019) highlights that municipalities are unable to formulate specific demands, favoring a specific mode of transportation when they auction out rights to build real estate, etcetera. He explains that the lack of means of control in similar situations, constraints municipalities from steering companies and organizations from using land and instead of using maritime transportation. However, municipalities can demand a maximum level of emission. Given that maritime transportation reduces emission per unit transported, this is a possible mean of control. The municipalities could require emission levels low enough to force the usage of more sustainable means of transportation.

#### 6.1.2 Financial

Both the respondents and the literature highlights the lack of maintenance requirements for waterway transportation as a potential driver. Though it is worth noting that the public sector funds maintenance and repair for roads while the owner fund repair and maintenance in port and quays, most often privately owned companies and organizations.

The lack of investment required is disputed among the respondents. While one argues that the infrastructure for transportation is already in place, meaning the waterways, another highlights the lack of suitable quays of unloading and transshipment and claims that there is a need of a substantial investment required for suitable ones to emerge.

Nonetheless, the most significant financial driver, according to the interviewees, is the increasing possibility to achieve economies of scale. While several highlights explicitly the ability to reach economies of scale as a driver, others mentioned its benefits when requiring to transport large volumes of goods, its suitability for larger masses or the high capacity of the vehicles, which is something that should be beneficial when transporting materials similar to those being transported in the construction industry. Garberg (2016) (see Table 1) shows that per ton cargo maritime transportation outperforms rail and road in terms of cost. He also claims that the cost benefits of maritime increases with the distance, since the fixed costs such as port fees etcetera becomes a lesser part of the total cost, which is also mentioned by one of the interviewees.

The economic pressure in the construction industry is substantial, and that the logistics costs result in a substantial part is well established. The difficulty in achieving economic sustainability when using maritime transportation, as stated by respondents, makes it easier to understand their selection of transportation mode. Other respondents stated that it is generally tied to lower cost to utilize road network and that the difficulties of maritime transportation to achieve economic sustainability mean that it will not be economically competitive compared to road transportation. These statements imply that it is quite natural that maritime transportation is not as widespread in the construction industry. The marketing director (2019) even goes as far as to say that a decrease in the cost of transportation is a prerequisite for a modal shift from road to maritime transportation.

However, the interviewee's gives several solutions, or prerequisites, concerning requirements for maritime transportation to be economically competitive. Several respondents stress the requirement and importance of return goods. Others appealed for more funds from the public sector for tests of bearing capabilities of roads and potential temporary quays for unloading of goods. The maritime consultant (2019) stated that large volumes are a requirement, explaining during an interview that

while one of the strengths of maritime transportation is sea vessels capacity and the fact that they can transport large volumes at once, this is not only a benefit but also a disadvantage. It requires large volumes in order to gain economies of scale and thereby be competitive towards other modes of transportation. Another respondent also mentioned that the volumes being transported usually are too small to reach economies of scale, thus making the transportation mode economically unsustainable.

Concerning the prerequisite of available return, goods are mentioned both in literature and by the respondents. It is argued that the requirement of truck transportation in the beginning and the end haul of the journey means substantially higher costs than sustainable, at least compared to door-to-door transportation by truck. However, it is also mentioned that if the construction site is in proximity to the waterway being used, there could be a possibility that the last transshipment from a vessel to truck might be eliminated, thus changing the cost structure completely.

### 6.1.3 Infrastructure

Interestingly, there were several recurring answers regarding infrastructural drivers for a modal shift from road to maritime transportation, and multiple of these are not established in the literature. One of these was that two respondents experienced a lack of truck drivers in Sweden. This is naturally a barrier for road transportation and only an indirect driver for maritime transportation, but the phenomenon is intriguing regardless. It would seem that the demand for transports of construction material has increased and the supply of Swedish truck drivers is unable to meet this increase, according to the interviewees. Further, the fact that this mismatch in supply and demand have not resulted in a modal shift supports The KMA director's statement, namely that an increase in foreign haulers with foreign truck drivers has occurred instead. The standards of these trucks, regarding for example levels of emissions produced, are naturally more uncertain compared to Swedish trucks.

Another interesting advantage of maritime transportation, IWT in particular in this case, not explicitly used as an argument in the literature, is the ability to utilize barges for additional storing in proximity to construction sites. This quite clearly ties into another driver highlighted by interviewees, namely the lack of storing area on construction sites in central parts of larger cities. It is an interesting addition of another type of driver, to use IWT not solely as transportation but in addition to increasing effectiveness of the project process. Vrijhoef and Koskela (2000) explicitly mention a dependable material flow as key within construction logistics, which the possibility of increased stock on-site would generate.

The driver for a modal shift that was highlighted by the highest number of interviewees was, however contextual. For maritime transports of construction material to be utilized successfully, the construction project requires to be situated near a natural waterway, according to the respondents. The reasoning from several interviewees regarding this consisted of the fact that other benefits of utilizing maritime transportation decreased if this was not the case. The congestion issues in proximity would naturally not be solved if the construction material required to be transported from a port or quay by truck, and the lack of truck drivers would remain an issue. The cases in this study all include the availability of waterways in the proximity of the construction site, utilizing IWT to access it. Since the use of maritime transportation of construction material is not widespread in any sense, it is reasonable to presume that cases, where it is utilized without waterways in the proximity of the construction site, is rarely planned or investigated. This also ties into the characteristics of construction logistics. Having temporary supply chains (as described in section 2.3), it is naturally a goal to reduce the complexity of these to an as high degree as possible. In construction projects not in the proximity of passable waterways, utilizing maritime transportation would only increase complexity, since the last distance would require road transportation as well.

In general, the infrastructural drivers for a modal shift provided by the respondents are noticeably contextual compared to the literature. Since each respondent, except for the experts, were interviewed regarding a specific case, this might be expected. For example, the literature describes the requirement of road networks and their capacity as a driver for maritime transport. The respondents, however, have no particular reasoning regarding this, other than congestion in the proximity of the construction sites (which this study examines as an environmental driver). However, interestingly all cases refer to transport of construction material which is not transported through standardized units. Concrete masonry units are the intended cargo in all cases except Slussen, and the literature supports that these types of cargo are increasingly beneficial when using maritime transport in general and IWT in particular, as described in the frame of reference.

The results from the interviews regarding infrastructural barriers are somewhat spread. Several respondents mention infrastructural barriers in general terms, highlighting single examples. However, the probable requirement of extra transshipment is discussed by multiple interviewees. This is a barrier which ties into several others since an extra transshipment point will result in additional cost and administration. Besides, a longer lead time is to be expected. This barrier is also discussed briefly in the literature, supporting the respondents' argument. Another barrier where consensus is reached between the literature and the interviews are the quality of waterways. Naturally, the respondents are detailed in their particular case, e.g., buoyancy, lack of paved shoreline, etcetera.

It is clear that investments in infrastructure are required in most cases to achieve a successful modal shift. However, nature and size vary greatly depending on contextual factors. Testing the buoyancy of waterways and quays and purchasing special cranes in Gothenburg for the Uddevalla-case is probably a more substantial investment compared to pave shoreline in the Karlstad-case. However, much larger volumes of cargo would potentially be transported in the Uddevalla-case, making the comparison difficult. In general, the respondents do not view these investments as insurmountable obstacles, rather the opposite. The distribution of responsibility and cost of performing them, however, seem to be a more significant issue.

#### 6.1.4 Environmental

The drivers of the Karlstad case are heavily focused on environmental benefits of a modal shift, with all interviewees highlighting it. This is very similar results to all the other cases, being mentioned in all cases, as well as by several experts. However, the focus from the interviewees is strikingly often the reduction of congestion such a shift would result in, rather than a reduction in emissions. A reduction of congestion is naturally visible to a more considerable extent compared to a decrease in emissions, explaining this focus somewhat. Congestion in central parts of Sweden's larger cities is also obviously considered an increasing issue, being a central part of the drivers highlighted by a vast majority of actors in all cases. However, congestion and emissions are by no means utterly separate concept, in the sense that an increase in congestion will almost inevitably increase emission. Further, noise levels are also closely tied to congestion in cities. The connection between congestion and high levels of emissions is highlighted by The KMA director (2019) in the Uddevalla case where the construction company she represents view a modal shift as a mean to reach environmental goals regarding both emissions and congestion.

In general, statements and conclusions presented in the Frame of reference regarding environmental driver for a modal shift are supported by the interviews performed in this study. Utilizing IWT is included in several of the cases, and statements such as "IWT perform very well, resulting in far less emission and congestion compared to road transport" by Wiegman and Konings (2017) is supported by interviewees. The holistic viewpoint provided by The CEO of M4 traffic (2019) is interesting in this context. Focusing solely on the socio-economic costs tied to different transport arrangements, it distinguishes itself by having no obvious bias based on generating profit for an individual actor.

Besides, the transport arrangement which his organization performed a socio-economic calculation is similar to several of the cases examined in this study. The fact that the modal shift was considered beneficial from a socio-economic viewpoint but still was not implemented is particularly intriguing. Sustainability was not included in a financial analysis of the case, probably due to the difficulty of quantifying such a cost (or revenue) for single actors in a supply chain. In this sense, the KPI suggested by Ying, Tookey, and Seadon (2018), namely vehicle movement would be an interesting addition when evaluating performance in construction logistics in general and environmental performance in particular.

The matter of decreased energy consumption, which, according to the literature, is a benefit of maritime transportation, is not explicitly mentioned by any interviewees. This benefit is likely closely tied to the financial driver, i.e., a decrease in energy consumption for one transport will result in a decrease in cost for that transport.

In conclusion, environmental considerations, in general, might correctly be considered as the main driver for a modal shift from road to maritime transportation according to both literature and participants in this study. The possibility to reduce congestion in central parts of larger cities in Sweden was considered the main benefit in a majority of cases. The reduction of congestion could be viewed as the singularly most important driver for initiating several of the cases in this study, both the executed and canceled ones. The reduction of emissions and noise levels is essential factors as well, both individually and as an effect of reduced congestion.

The literature discusses some negative environmental aspects of maritime transportation, including air emissions, water quality, soil, waste, biodiversity, and noise impact. The respondents, however, does not discuss these. Port congestion in the Helsingborg-case is discussed briefly, though not as mainly an environmental issue but rather a scheduling issue.

An increase in noise impact due to a modal shift from road to maritime transports is not a fact, and a report from Stockholm stad (2019) showed that it is possible to load/unload barges three times per day without exceeding established guidelines from Sweden's environmental protection agency.

#### 6.1.5 Service quality

There seems to be a consensus between the literature and respondents that service quality is generally a weakness for maritime transportation. Both focus on it as a barrier rather than a driver for increased maritime transportation. The inflexibility of the mode and more specific issues like lead times and the inability of frequent deliveries is something brought up by literature and briefly mentioned by the respondents. With inflexibility comes a lack of JIT capabilities, which is essential for the construction sector, mentioned both in literature and during our interviews. However, the literature argues that the most common cause of delay during construction projects is the lack of materials, and thus a large delivery by maritime transportation at the initiation of the project could be tempting. However, there is also a lack of space on construction sites and in their proximity, making continuous deliveries of smaller batches of materials necessary.

#### 6.1.6 Administrative

There are not much written in literature about the administrative issues related to regular shipping, without any of the standard intermodal properties, like a single cargo container. Nonetheless, Garberg (2016) states that maritime transportation requires a significantly higher amount of administrative work than both road and rail transportation. He writes that while road transportation only needs a bill of lading and customs documents, sea vessels require multiple documents when handling cargo, especially if they are to dock at a port.

The respondents did, however, raise several issues related to administrative barriers. For example, The goods strategist and the maritime consultant (2019) raised the issue of transshipment. That instead of just having to load the cargo on a vessel once before arriving at the end customer, it now has at least two reloads. First, from the truck to the sea vessel, and second, when it arrives from its sea voyage, it had to be reloaded to a new road vehicle. Other issues being brought up by the interviewees are mostly related to the coordination and cooperation required by the different parties. How different suppliers have to work together to achieve the volumes required to reach economies of scale, but do not because of pride and unwillingness to cooperate with competitors.

#### 6.1.7 Other

While most drivers and barriers are quite easy to categorize based on previous literature, some are not previously mentioned and maybe not related to the subject of construction logistics in terms of a pure research topic. However, according to the respondents, it seems to be, and it being behavior and habit. Several respondents mention habit and prejudice as a transparent barrier to why there has not been an increase in maritime transportation, discussing that the fear of the unknown and change is perhaps one of the most critical barriers to overcome. The industry has been stuck with using the roads and trucks for such a long time, and all the solutions regarding tolls and driving routes have evolved to a level where it feels unnecessary to change. As one of the respondents said;

With the current logistics solution system performing on such a high level, the construction companies and their partners see no reason to change. Either customer needs to start putting harder requirements on construction companies, or their governmental agencies need to start setting their foot down and demand. However, several respondents have claimed that there seems to be a lack of interest from politicians and feel like they do not get the response they want when seeking support from their municipalities. The freight traffic manager believe that this might be a result of lack of knowledge and competence among governmental employees about the benefits of maritime transportation and the lack of knowledge could be a reason for why they do not seem to take any interest in the propositions the respondents and their companies have pushed for.

The maritime strategist highlights another intriguing aspect when he mentions that the idea of using waterways for transportation is considered in a stage where it is usually too late. He explains how the idea needs to be considered and investigated in the procurement phase, but often is considered in a much later stage where it is easy to wave it away as unreasonable or that the process has gone too far.

### 6.2 Cases - a comparison

*In this section, an analysis based on the answers from the different cases is presented.*

The cases studied in this paper have some differences which are essential to acknowledge, as is illustrated in Table 5. The Uddevalla case is a business case, initiated by the port of Uddevalla while the other four are initiated from either the city or municipality, of course in cooperation with other actors. This difference is significant since it naturally puts an increased focus on financial sustainability when performing a business case. Further, the degree to which the cases were planned varied significantly. The Stockholm bypass project effectively used maritime transportation to transport contaminated soil away from the construction site. However, the transport of concrete masonry units to the site was not active when this study was performed. The Slussen case is planned and will be carried through, however in no small extent due to the one-of-a-kind cargo. The Uddevalla case was planned in detail, with the possibility to operationalize, through a flow of return goods was required to able financial sustainability. However, the Karlstad and Helsingborg cases were only theoretically planned, being discussed between actors in the supply chain and the respective city officials and after that, put on hold. This naturally limits the extent to which these two cases can be examined in detail.

However, in order to research drivers and barriers of a modal shift, these are interesting since the actors involved probably naturally experienced both, initiating and stopping it.

#### 6.2.1 Drivers

An observation when reviewing the drivers of the different cases, the most obvious observation is the extensive focus on environmental benefits of a modal shift among the interviewees. It is a recurring category of drivers in all cases and among multiple experts. Infrastructural drivers are also mentioned in each case, though not as often or thoroughly explained as environmental. These are often contextual, specific for that individual case. Regarding financial drivers, they are discussed in all cases but Uddevalla, which is notable since it is the only clear business case. The benefits of utilizing economies of scale and long-distance transports seem to be an opportunity which interests some actor in all cases. Drivers related to laws and regulations are less discussed by the respondents in general, however in the Uddevalla and both Stockholm cases weight restrictions on roads are mentioned as drivers for a modal shift. Since the roads in the Uddevalla case discussed are located in central Gothenburg, it is natural to assume that this connects to the fact that the cases are performed in the two largest cities in Sweden.

#### 6.2.2 Barriers

The barriers in the cases are distributed evenly in terms of what categories are discussed to a more significant extent compared to the drivers. Similar to the infrastructural driver, the infrastructural barriers are discussed by all cases and experts, and the contextual factor is significant. A clear example is the Helsingborg case, where frequent ferry traffic in the port resulted in difficulties to add barge traffic. This is an obvious barrier that is difficult to eliminate and focus in this case could be shifted towards drivers, reviewing what benefits such a modal shift might result in.

Interestingly, the category called “other” contains a large number of barriers. After reviewing these, it is quite clear that a habitual perspective exists, and that it spans over close to all cases. A disinclination towards a shift in itself seems to pose the main barrier, according to at least one respondent in close to all cases, and several experts. It is clear that even though this barrier was sparsely discussed in the literature, it is valid for all cases and not dependent on contextual factors.

### 6.3 Actors and roles – a comparison

*In this part of the chapter, a comparison between the different actors is presented.*

#### 6.3.1 Drivers

*In this section, the drivers addressed by the different actors and roles are compared.*

##### 6.3.1.1 Laws and regulations

Concerning laws and regulations as a driver there where only one municipal employee and one employee at a construction company that chose to highlight it. They both mention the weight restrictions in Stockholm and Gothenburg as a driver, meaning both organizations is aware of it and consider it.

##### 6.3.1.2 Financial

By examining the financial driver no significant difference between the different actors except for the shippers, they both argue that there are less infrastructural investments required compared to road transportation. While the other respondents choose to focus on the ability for maritime transportation to reach economies of scale, this is quite interesting and perhaps something that could be further investigated why it is this way.



#### 6.3.1.3 Infrastructure

Given the previous concurrence among the interviewee's, the opinions and arguments concerning the infrastructural driver quite different. While four out of five municipal employees mentioned construction sites being in proximity to a waterway as a potential driver, only two out of the remaining thirteen mentioned it. Why this is the case is perhaps something to investigate further, since for example none of the two who worked in governmental agencies who work with logistics, one as a maritime strategist and the other as a freight traffic manager, mentioned it. Otherwise, there are no obvious connections or comparisons to be made. Three out of eighteen mentions barges as possible warehouses for goods if there is a lack of space, three out of eighteen spoke about the infrastructural congestion relief maritime transportation would have on-road transportation, and two out of eighteen mentioned the lack of truck drivers in Sweden as a driver.

#### 6.3.1.4 Environmental

Just like when glancing over the financial driver, there seems to be a consensus among the interviewee's about the main drivers, being emissions and congestion-related in this case. Ten out of eighteen mentioned emissions or reduced environmental impact, while thirteen mentioned congestion and congestion-related issues, meaning congestion is the most prominent drivers, according to our respondents. Although all respondents mentioned more or less the same, The CEO of M4 traffic (2019) brought up another aspect, namely the socio-economic and explained that compared to road transportation, it is more socio-economically sustainable.

### 6.3.2 Barriers

*In this section, the barriers addressed by the different actors and roles are compared.*

#### 6.3.2.1 Laws and regulations

There are no apparent similarities between different actors and their view on how laws and regulations effect. However, there are some small things which segregate the different actors from each other. For example, there are only municipality workers (two of them) and the maritime strategist, who is employed by a governmental agency who highlights the issue of actual laws that prohibit the usage of maritime transportation. They say that lack of clear means of control, and permissions from multiple different actors and strangely constructed environmental regulations constrain the development.

In total, five out of eighteen respondents highlighted some law or regulation as a barrier. Except for the three governmental (in some level at least) two others mentioned something that these three did not which relates to laws and regulations. Namely, the poor implementation of the governmental bonus-system Eco-bonus, and the difficulty to apply for it. However, this could very well have been because they did not know of it.

Noteworthy is that while only two of eighteen mentioned the bonus system, the two who did focus on the poor implementation of it and how confusing it was. The maritime consultant also said that the only ones who could apply were the shippers, and none of the shippers we talked to mentioned it as either a driver or barrier, which could be seen as a failure since none of them knew or at least highlighted it in any form.

#### 6.3.2.2 Financial

There are no significant conclusions that can be drawn when comparing the respondents and their answers based on their roles. Nonetheless, there are a couple of minor, quite interesting marks to be done. For example, three respondents mention a lack of investments from municipalities (a shipper), the public sector (a governmental employee) or just infrastructure investments in general (construction company) as a barrier. The interesting point is that none of them come from the same role or organization and that none of them work in a municipality. This could mean that either the

municipalities see it as their role to invest in infrastructure which develops the capabilities of maritime transportation or they are not aware that it is a requirement.

#### *6.3.2.4 Infrastructure*

One interesting aspect to consider when comparing roles and actors is how none of the shippers mentioned any physical aspect when looking at physical barriers. The only things mentioned by them are that the industry has well-established solutions for land-based transportation, while no such thing exists for maritime transportation. This has only one respondent out of eighteen pointed out, however, it could be connected to the habit factor which several respondents mentioned, but it could also be argued that they are not related and the second is just a result of the first. Nonetheless, while several different respondents mention different physical barriers such as buoyancy capacity limits on quays, lack of space, cranes requirements, etcetera. The shippers seem not to be concerned by this as a significant barrier and instead focus on others.

#### *6.3.2.5 Environmental*

Concerning the environmental barrier, there is not much to be said. Only two actors mentioned any barriers, and they were both from the Helsingborg case. To be noted is that they have different roles and different employers, one from the municipality and one from a construction company. This means that they both have knowledge of the issue and why it is crucial to consider it when reflecting upon why maritime transportation is not utilized in proportion to its potential.

#### *6.3.2.6 Service quality*

Compared to how often literature mentions the flexibility and lack of JIT as a barrier for an increase in maritime transportation, the respondents were not so keen on highlighting the barrier as crucial. However, among those who mentioned it one was from a municipality, one from a port, one was working as a consultant, and the last was working as a shipbroker and consultant. This means that none of the shippers or the people working in construction companies mentioned it. Regarding the respondents who worked in a construction company, this could be because they wanted to highlight other aspects or forgot to mention it. However, it is still quite interesting as the people who should be the keenest on wanting to maintain the flexibility of road transportation is the construction companies, since much of their system build on smaller, but continuous deliveries together with flexibility if the customer wants any last minute changes. Why the shippers stayed away from the topic could perhaps be because they saw it as the main weakness of maritime transportation and therefore choose to highlight barriers which could be solved in the near future. For example, investments from municipalities for weight bearing tests, etcetera. Instead of having to develop sea vessels with properties and performance as a truck.

#### *6.3.2.6 Administrative*

Four different respondents mentioned coordination and cooperation between different actors as a barrier which needs to be improved to enable increased usage of maritime transportation. One of them worked in a construction company, one in a governmental agency, and both of the respondents who were from ports mentioned it. That both the port employees mentioned can either mean that it is something that is identified as an issue among ports and their employees, or it is just that the two persons we interviewed have knowledge of it and does not represent the larger masses of people who work in ports. Except for people working as shippers or in a municipality, all groups we interviewed were represented. This could perhaps be because none of those two actors have any personal experience of a lack of coordination and cooperation because they are not a part of the parties which needs to coordinate. However, The freight traffic manager, the person who works in a governmental agency among the interviewees who mentioned a lack of cooperation and coordination also advertise for more cooperation among municipal instances. He believes that this would enable increased usage of maritime transportation.

#### 6.3.2.7 Other

When examining the answers from the respondents related to the “other” category, there are some issues that keep on emerging. For example, lack of knowledge among employees in municipalities is mentioned by several actors, and it is the same with lack of interest and lack of action from politicians. The answer is given by a quite wide range of different actors, meaning that the issue is not just during a single case, but perhaps in general and an area which is pretty easy to define as a potential improvement area.

Another interesting answer is the habit and prejudice issue or conservative builders and politicians, that they have always used road transportation and it has worked, so the issue becomes to argue why construction companies should change an already well functioning concept. Two municipal workers and one contractor provided the answer, so it was not raised by any of the respondents from construction companies. This could, in some ways, be expected since it is towards them the critique, is directed. Road transportation is partly so attractive because there is no need to draw any new contracts because there are standardized tariffs.

### 6.4 Recommendations

To reduce the need for transshipment, and perhaps even eliminate it, advocates of maritime should focus on projects close to the seaways. As these could use the waterway without relying on the last mile transportation by a truck, which is something several respondents highlighted as a severe issue during our interviews. Also, areas, where there are severe congestion issues, should be targeted, as these are the ones that could have the most benefit as identified in the interviews. Focusing on congestion and targeting areas where it is a real issue seems to be the critical factor to increase the usage of maritime transportation as it was the driver who was mentioned by most respondents.

As mentioned above, the projects targeted should be in areas where the congestion is the highest and that are near the water. However, for this to be even possible, further suitable quays for unloading and transshipment needs to be established. If not permanent, at least temporary, and for that to be possible municipalities need to fund weight-bearing test or supply financial aid for these temporary loading spots.

Further actions are required from politicians in upholding road restrictions and coordination of regional regulations. For example, more decisions like the one where the Swedish government forced materials for the construction of bypass Stockholm tunnel project needs to be made. Instead of decisions similar to what the municipality of Gothenburg made when they disregarded the weight-restrictions, they made themselves and let the road transportation traffic drive upon weight restricted roads with too heavy cargo.

Another issue raised was the incentive system called Ekobonus. The application process was considered to be poorly constructed, making it hard to apply, and unclear who could apply, for what, and so on. Instead, money could be spent on reducing those costs that prohibit maritime transportation as identified by previous literature — reducing harbor fees, sea vessel registration fees, and fees related to the materials transported.

Another transparent barrier identified was how habit and prejudice play in with the transportation mode selection process. This study showed that the idea of shifting transportation mode from the more traditional road transportation to maritime transportation often emerged too late in the process. To prevent this, construction companies need to start to consider other modes of transportation from the start of the initial planning stage of the project. To ease the transition, developing standard agreements between shippers and construction companies could be considered as well. As this was

something mentioned during the interviews as something that could impact the selection process, making it easier to select road transportation due to the lower workload required for booking of transportation service and drawing contracts with shippers.

## 6.5 Reflections

This chapter provides reflections on the results of the thesis. Subjects related to the thesis that has not been examined in depth are explained and motivated.

### 6.5.1 JIT deliveries

When examining the freight transportation market in the construction industry from a broader perspective, it is quite clear that maritime and road transportation have such a difference in characteristics and capabilities, making it hard equitably comparing them. This result in the current construction industry today is heavily reliant on the exact characteristics that the freight transporting truck provides. It is reliant, extraordinarily flexible and can deliver on tight schedules. The lack of space often recorded on, and nearby the construction sites, makes the volumes each truck deliver suitable because they can time them in a manner in which they will be done with the delivery from one truck just before the next arrives for delivery in highly optimized schedules. Thus minimizing warehouse levels and at the same time keeping the construction continuously ongoing. For maritime transportation to be even considered in an industry which has adopted its ways towards a specific transportation mode, a considerable turnaround needs to be made. Perhaps it is time to look over the requirement of JIT deliveries because, after all, the most significant potential cost factor of construction sites is when there is a lack of materials because of delivery delays. Further on, the best solution when risking material shortages is to increase the batch delivery sizes, which is something that maritime transportation should be very suitable for. However, it also puts new demands on the construction company in terms of planning and space requirements.

### 6.5.2 Lacking proactiveness

There seems to be a lack of proactiveness among organizations, companies, and governmental instances regarding the potential effect of several construction projects nearby each other and the congestion issues that might bring. The concern was raised during our interviews, and it was argued that some municipalities would not take action until it is too late. However, when it happens, and the roads are clogged, the sea freight transportation vessels will be heavily sought after and in such a case price probably will not matter because the materials have to arrive at the construction site. It could even be argued that this is what needs to happen before politicians and construction companies take action and start examining and looking over the possibility of using maritime transportation.

### 6.5.3 Quantification of costs

It is quite hard to quantify the costs of road and maritime or waterway transportation in a suitable way. Partly because they are funded in very different ways, roads are usually funded by the public sector while private companies and investors fund ports. This is an issue since the socio-economic profits of an increase in maritime transportation instead of road is evident, which is an argument that the public sector should support and help and fund new ports. However, the public sector is often under strict budgets without any means of financing new infrastructure projects. However, then again, if the government of Sweden did not want to increase and promote maritime transportation, why would they introduce incentives like Ekobonus.

### 6.5.4 Contribution to previous research

Previous research within the topic mostly focuses on technical barriers and specific characteristics of the modes as a means of barriers for increased usage of maritime transportation compared to road transportation. The thesis brings up a new barrier barely mentioned in previous literature, namely,

habits and prejudices. Based on what the respondents argued during several interviews, habits and prejudices are not to be underestimated in an area such as the construction industry.

Another subject raised and rarely mentioned previously in established literature is the importance of proximity to waterways how the location of the construction project and the proximity to waterways impact the usefulness of maritime transportation and reduces some of the negative aspects otherwise prohibiting the usage of the transportation mode. The thesis highlights this and argues why it is of importance, with the help and arguments from the interviewees.

There also seems to be a lack of previous studies which highlights the importance of coordination between actors, such as private companies and the public sector, for maritime transportation to be successful. With the information gathered during the data collection state, this thesis argues why it is of importance, why it should not be thrown aside and instead be seen as an essential and viable barrier for a modal shift from road transportation to maritime transportation.

Previous research in the subject area lacks to mention the impact of bonus systems and how the construction of them affect the usefulness of them. This study clearly shows that bonus systems can be incentives, given that they are constructed sufficiently.

#### 6.5.5 Future area of research

This study was based on the thoughts and arguments provided by respondents during interviews. This means that the first, given area of future research is to compare the results from the interviews and the literature study with a quantitative study based on numbers and facts. A combination of the two would give an intriguing aspect to the study, either strengthen the result of this study or challenge them, providing some interesting results. A study focusing on the cost of the materials transported in combination could also be of interest as this according to literature plays an essential aspect in the selection of the transportation mode.

Given the lack of previous research in the subject of the habitual barrier, a more comprehensive study focusing only on, or at least targeting the subject to a higher degree, with more in-depth interviews could bring interesting results. It is believed that this could bring interesting results as to why companies and organizations continue to using road transportation for most transports when other methods might be suitable and viable options to consider. There is literature that shows that the idea of using maritime transportation usually is considered way too late in the process, and it could be interesting for future research to investigate whether this is due to habit or due to something completely different.

This study focuses on cases from Sweden solely and of course, conducting a similar study where the same method is used but in more cases, from other countries and continents would be of interest. If studies from other countries and continents provide similar results, it would provide more viability to this study and perhaps lead to a possibility of comparing how different cultures tackles the problems identified by the thesis. There are examples from other projects in the world who have adapted to more maritime transportation and reduced transportation on roads, examples of how these succeeded would be of interest and to compare how they overcame the problems they faced.

## 7. Conclusions

*In this chapter the conclusions and the answers to the research questions will be presented. The chapter is divided into two parts: first, the main drivers and barriers identified for research question one is presented, followed by the solution to the second question.*

### 7.1 Research question one

*“What are the main drivers for a large-scale modal shift from road transportation to maritime transportation for construction material transports?”*

From the study, the following drivers were identified:

- Environmental, represented by the reduction of congestion and emissions
- Construction site in proximity to passable waterways
- The possibility to utilize IWT and thereby barges, gaining additional benefits
- Gaining economies of scale and lowering cost for transports over long distances

### 7.2 Research question two

*“What are the main barriers for a large-scale modal shift from road transportation to maritime transportation for construction material transports?”*

From the study, the following barriers were identified:

- Habits and prejudices benefiting road transportation
- Flawed national bonus systems for maritime transportation
- Significant fees connected to utilizing maritime transportation
- Addition of extra points of transshipment
- Lack of knowledge regarding technical aspects and benefits of maritime transportation in the public sector
- Lower performance regarding flexibility
- Larger volumes result in higher investments of each transport
- Infrastructure for efficient utilization of maritime transportation in general and IWT, in particular, require investments, e.g., in order to construct quays and performance of bearing calculations.

### 7.2 Research question three

*“How can these barriers be overcome, and drivers be accentuated?”*

When analyzing the answers provided by the respondent in the case studies and the literature, several conclusions regarding how to overcome barriers and accentuate drivers can be identified. Environmental considerations when selecting transportation mode are required. An example on how to perform this is to put congestion and emission as cost items and attempt to quantify these. Another is to force proactiveness and planning from construction companies by demanding an estimation on what levels of congestion and emission the project transport will produce. In order to successfully perform a modal shift, considerations must arise at an earlier planning stage, i.e., in the procurement phase. Hence, such a demand from the municipality or city would incite proactiveness. Also,

construction projects in proximity to waterways could potentially be forced to investigate the possibility of maritime transportation.

As the literature suggests, higher volumes and longer distances benefit maritime transportation, according to the respondents in the case studies. These are the construction projects which efforts should be directed.

The bonus system, Ekobonus, aimed at moving freight from road to maritime transportation, require reconstruction in order to be effective. However, there are two aspects to be considered. Partly, the bonus system is flawed, and partly, the fees for conducting maritime transport activities in Sweden are high. A system where fees are reduced if the project move freight from road to maritime transportation should be reviewed in order to reduce steps and streamline the process. Also, a bonus system with a broader window of the application and a review of requirements to obtain the bonus could increase incentives for a modal shift.

In order to overcome the habitual barrier, further research and efforts should be directed towards this issue. In addition, the habitual barrier could be overcome by political constraints, adding requirements of examining the possibility of maritime transportation for construction projects in the proximity of passable waterways. This constraint should be implemented at the planning and procurement phase of the construction project, in order to for to be thoroughly considered and not rejected due to inconvenience.

In the cases studied in this thesis, a common denominator for those where a modal shift was successfully carried out or planning was still ongoing with intent to execute were strong political support and constraint. In order to achieve a modal shift to a more significant extent, that support will be necessary. Often the thing lacking was the knowledge and information regarding maritime transportation of construction material and its effect on congestion and emissions requirements to increase in the public sector, according to several interviews in this thesis. Another barrier connected to this fact is the lack of essential infrastructures, such as quays with sufficient bearing. To increase knowledge both regarding the benefits and the investments required in order to achieve a modal shift from road to maritime transportation is paramount.

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